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Metals and Alloys

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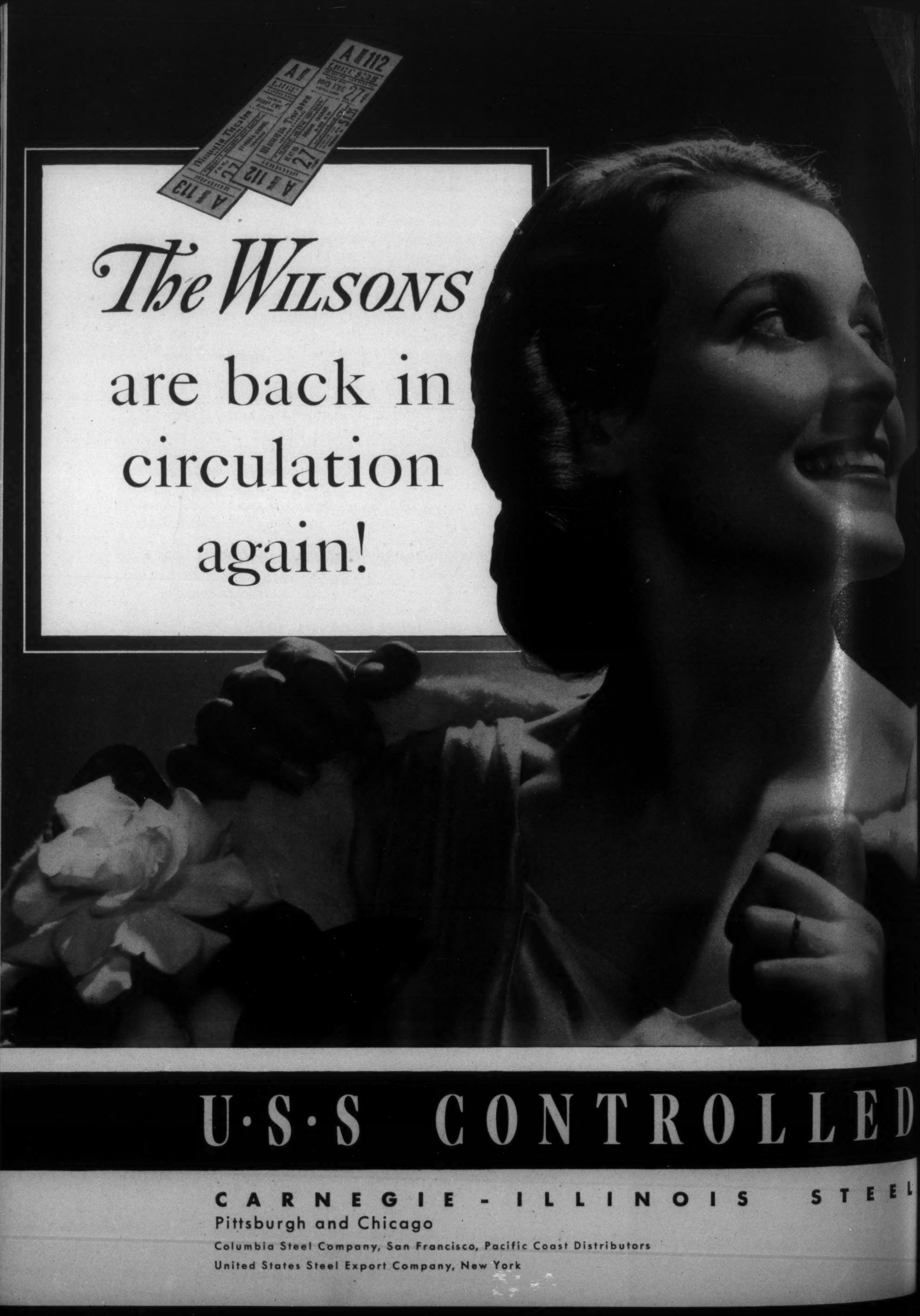

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BY HERBERT CHASE

Will Plastics Displace Metals?

We have heard frequently the statement that plastics will displace metals. One meets several arguments on both sides.

Desirous of giving our readers an authoritative discussion of the possible competition between metals and plastics, we solicited an article by Mr. Chase, who is regarded as one of the best-posted writers on plastics, die castings, stampings, and kindred subjects.

His conclusions are that the two types of materials are basically different and consequently that their uses seldom overlap or become competitive.—The Editors.

NO TWO PERSONS WOULD BE LIKELY to make precisely the same answer to the question, "Will plastics be substituted for metals?" Some enthusiasts have reached the conclusion that they will do so in a large way. A more conservative answer is that such a substitution, except in a limited number of isolated instances, is highly improbable. It is one purpose of this article to present evidence supporting this latter conclusion.

Having studied plastics intensively for many years, the author is well aware of their utility in a rather wide range of uses. This utility is really not in dispute and is here acknowledged. Plastics have, in fact, grown in importance so rapidly that it has become easy for superficial observers to jump to the quite unjustified conclusion that plastics are on their way toward crowding metals more or less out of the picture.

If so broad a conclusion were to gain acceptance, it might easily result in almost irreparable injury to the cause of plastics. Certainly nothing would be gained and a great deal will be lost if plastics be substituted for metals and their alloys in cases where these materials are really better suited for the purpose than are plastics. As will presently be demonstrated, plastics are often used to supplement or complement metals—rarely indeed to take their place.

Plastics Have Many Uses

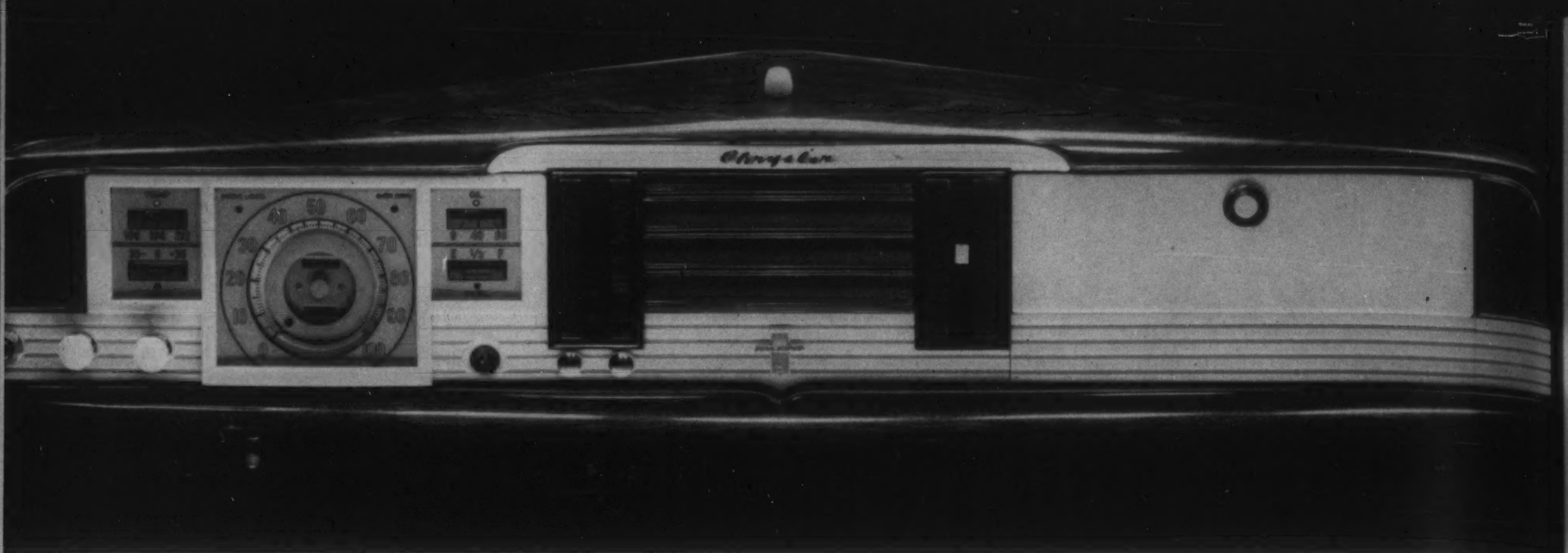
No honest and qualified observer will question that plastics are well adapted to many uses. They are excellent dielectrics. They serve well in numerous decorative applications. Most of them are lighter and less active chemically than most metals. Many have translucent or transparent properties which metals do not have. Several other advantages might be cited, not forgetting the fact that plastics often come from the mold substantially ready for use and they rarely require an applied finish.

But how easy it is to make an even more imposing list of advantages possessed by metals and their alloys! Metals are generally good conductors of electricity (without which there would be no need for dielectrics). Metals serve decorative purposes to a far wider extent than plastics do. Although nearly all are heavier than the heaviest plastic, their strength, ductility and resistance to impact are far greater. Many metals and alloys are suited for use without applied finishes and many come from dies substantially ready for use, just as plastics do. To be sure, many metals require an applied finish to suit them for certain exposures, but many such finishes are quite inexpensive and many alloys do not require them even for outdoor exposure, whereas few plastics are recommended in any event for continued outdoor exposure.

In short, both plastics and metals have their advantages, as well as their limitations. In certain border-line cases either can be substituted for the other, but the proportion of such cases is small.

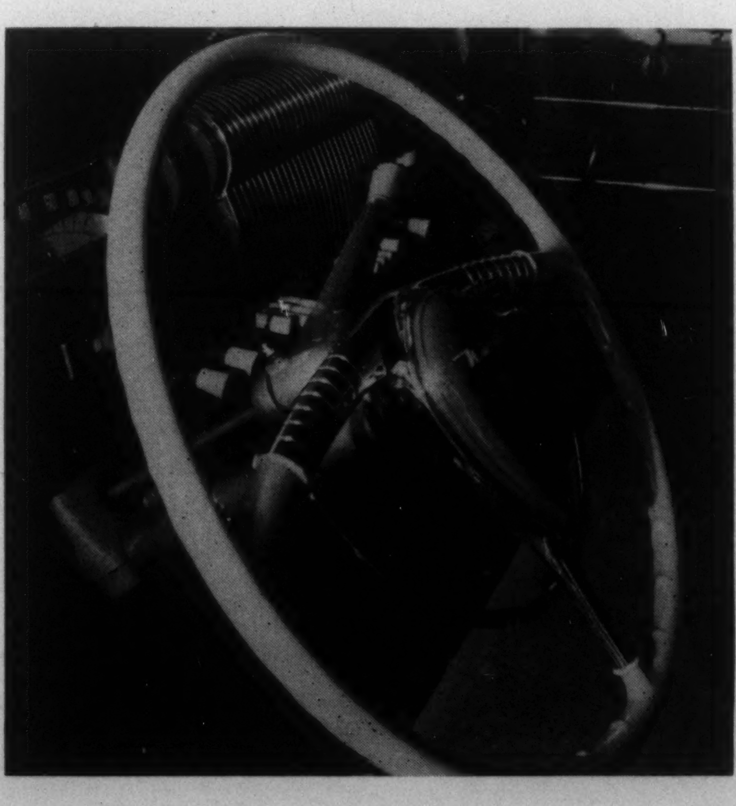
Certain Limitations of Plastics

It is necessary, however, to go beyond these generalities to satisfy those who want a more specific answer to the question, "Will plastics displace metals?" In doing so it will be necessary to point out certain limitations of plastics. This should not be construed as prejudice any more than it is to say that metals and alloys also have their limitations. But the simple fact is that some persons have postulated the extensive substitution of plastics for metals (as



This Chrysler instrument panel uses much more plastic than is commonly employed, but the panel proper is a steel stamping, as on all American cars. The glove door is also a steel stamping, but is covered with an attractive translucent plastic, "Tenite," which is used also for the other light colored trim. Darker parts at center are die cast in zinc alloy.

in the major elements of automobile bodies, for example) and any fair consideration of such an assumption necessarily involves weighing the evidence in the case. If the conclusion is not favorable to plastics, one should quarrel with those who have advanced the thesis, not with those who show it to be without sound justification.



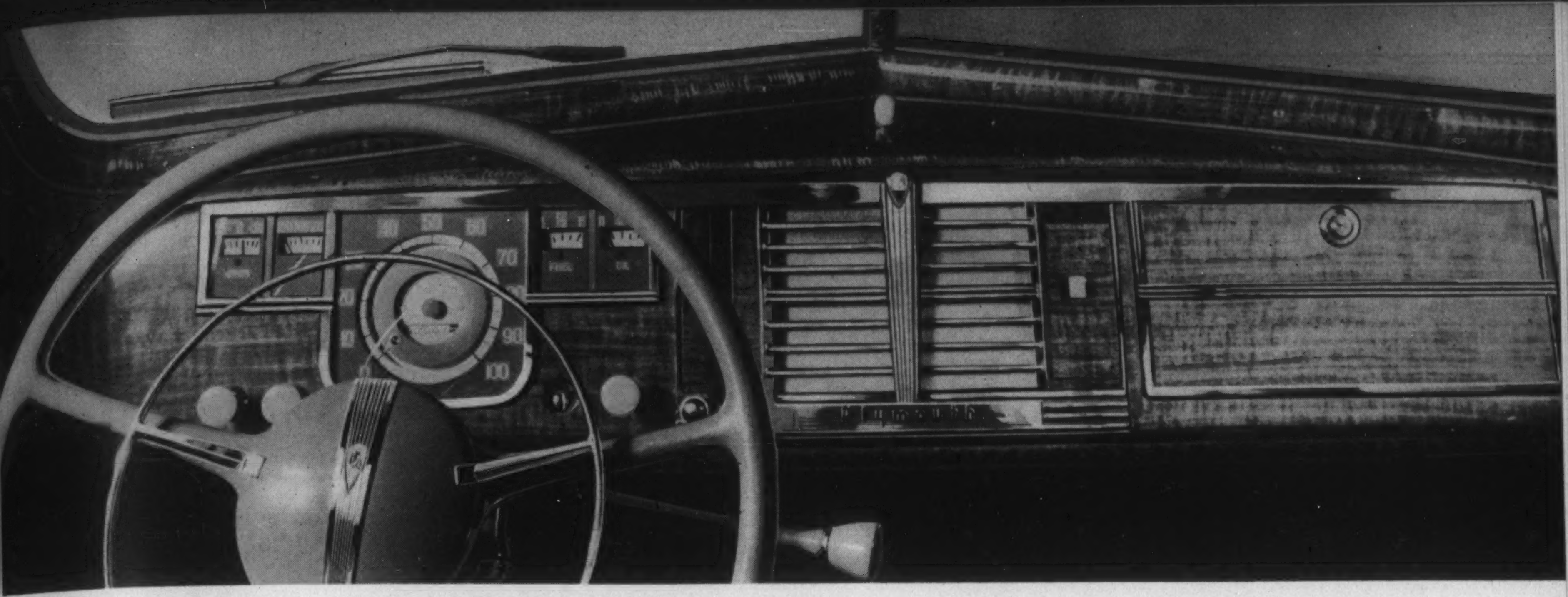
Nash front compartment, showing several parts, such as steering wheel hub, horn ring, shifter lever, radio grille and interior hardware die cast in zinc alloy. The core for the plastic covered steering wheel, parts of the spokes, steering column, shifter rod and instrument panel are steel. Knobs, horn button and instrument lenses are in plastic, used chiefly for decorative effect and where transparency is desired. Parts requiring strength are all metal or plastic reinforced by metal.

It should be understood that references to plastics here apply to the synthetic types. In some degree they apply to rubber, the most important of all plastics, but in other cases they do not apply, hence, for simplicity's sake, rubber may be considered as excluded from this discussion. The first synthetic plastic (pyroxylin type), now some 75 years old and still in wide use, remains among the more expensive types. Much less expensive and in widest use is the phenolic type, introduced over 30 years ago. This is the cheapest form in wide use, yet it sells in large quantities for about 12c per lb., minimum, for the general-purpose grade. Most other forms, including those which are transparent and translucent and which come in the many beautiful colors, about which much is said, range in price from about 30c to $1.00 or more per pound.

It is true that plastics are much lighter than metals, but even on a strength-weight basis they nearly always cost considerably more than the commoner metal and frequently more than metals and alloys of intermediate price. This is not always true in the fabricated forms of both types of material, but it usually is when the plastic part is made as strong as that in metal.

Plastics More Expensive

It is significant that, after more than three decades of development, plastics are usually more expensive than metals, even on a part-for-part basis, which, of course, is a considerable handicap. There is much talk of cheaper plastics and some evidence that they are likely to be developed, but this is largely speculative. There is little to indicate that these cheaper forms, when and if available, will become so in the attractive colors so often associated with plastics but confined at present to the more ex-



Plymouth steering wheel and instrument panel, 1940 model, typical of many in current use. The only plastics seen are for small decorative parts and the wheel rim (molded over steel). All remaining parts are in metal either die cast or steel, many of them having decorative value not exceeded by that of the plastic part.

pensive types. Clearly, if plastics are to displace metal in a large way, costs must be competitive and, to date, the evidence that they will be is, at best, far from being convincing.

When the strength of plastics and of metals are compared, plastics are almost always greatly inferior. Nearly all plastics, and especially those suitable for molding, must be classed as relatively brittle. The ductility and toughness which characterize steel and most wrought metals are never approached in plastics. Even the common cast metals, some of which are relatively brittle as compared with wrought metals, are much less so than plastics. For molded plastics, 0.4 ft. lb. Izod impact strength is quite high for the standard ½ x ½-in. notched bar. As compared with this, some common cast metals show 20 ft. lb. or higher impact strength (Charpy ¼ x ¼-in. unnotched bars, *one quarter the sectional area of the plastic bar*) and of course many wrought metals show a much higher impact strength than cast metals do.

There is somewhat less disparity as between metals and plastics in comparisons of tensile, compressive and bending strength but, in general, the difference is still pronounced. For example, plastic moldings range from about 5,000 to about 13,000 lbs. per sq. in., maximum, the latter figure being close to the highest for any molded plastic, and only a small fraction of that attained in wrought and even in many cast metals.

It is possible, of course, to reinforce plastics with paper, metals or fabric, as in laminated sheets, thus increasing their strength by reason of the reinforcement, but when this is done with sheet materials, the plastic is no longer readily moldable or at best cannot be molded in any but simple and shallow forms. Even then, strength is far short of that attained with most metals. Those who talk glibly of plastic automobile bodies, either do not know or overlook such considerations. They lose track of the fact that steel not only makes a strong and ductile body structure, but in forming is flanged, stiffened and reinforced as no plastic with a paper, fabric or similar filler could be on an economical scale.

Strength of Plastics

Thus we reach the second conclusion: That plastics lack the strength to be substituted for metals, save, perhaps for a few small parts which, even then, are likely to require metal reinforcements. Lest some raise the question, "What about plastic instrument panels, already used in passenger cars?," it may be well to answer that no American car has such a panel. The panel itself is sheet steel. A few have plastic parts as large as glove doors, but some of these are molded over steel and those which are not so reinforced are thick and expensive and still fit into or over a metal panel. Most cars, including some on which plastics have been tried and dropped *for large parts,* now have die cast zinc-alloy radio grilles, instrument frames and glove doors or use equivalent parts in pressed steel. In most cases, the use of plastics on instrument panels is confined to knobs, small decorative parts and instrument lenses, for which plastics are well suited, thanks largely to their attractive color and translucency or transparency.

A third consideration is the time required and cost involved in molding, especially of large plastic parts, as compared, for example with the rapid stamping of steel or the die casting of zinc and of aluminum alloys. It is generally conceded that the only type of plastic suited for large moldings are the thermosetting forms, which are not subject to softening if heated after molding and show a minimum of cold flow under load. But the largest moldings produced to date require a minimum of 10 minutes, and sometimes much longer, for the complete molding

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All of these decorative parts in cellulose acetate or acetate-butyrate plastic are used in 1940 cars, but in every instance they are used in close association with steel or other metal which gives the required strength and is lower in cost.

cycle. How far would one get in large quantity production with less than 50 parts per 8-hour day? With small plastic parts, the total can be stepped up by using multiple-cavity molds, but for really large parts this is not feasible. One might use several molds in separate presses, but molds are expensive and many presses with many operators involve high overhead and high labor costs; far higher than for stamped or even die cast parts.

With thermoplastics, which are more costly materials and are subject to softening again if heated after molding, one can save in molding time by using injection presses for pieces up to about 2 lb. in weight, but, besides the higher material cost, the feasibility of large parts inclined to warpage and dimensional changes and subject to cold flow is yet to be demonstrated. Even then, a one-minute molding cycle would be fast on parts weighing 2 lbs. or more. So again we find plastics at a disadvantage as compared with metals, since die casting machines now yield six or more good size pieces *a minute* and stamping presses run at still higher rates. To date, the 2-lb. weight, cited above, is the maximum for injection molded plastics and requires a very expensive machine with multiple injection units. Moreover, injection molding requires pressures ranging from 10,000 to 20,000 lbs. per sq. in. and if presses suitable for molding major automobile body parts, for example, were to be used (even assuming such parts to be feasible, which is exceedingly doubtful) they would have to be of gigantic proportions and so costly that, at best, their feasibility is in great doubt, especially in view of their low production rate as compared with stamping presses.

Plastics Need No Applied Finish

It is true, of course, that plastics commonly require no applied finish and consequently they save, as a rule, the cost of finishing. This is sometimes an important advantage, but it applies only where the desired color is obtained in the molding itself, and it must not be forgotten that the cheaper forms of plastics come chiefly in black, brown and dark colors, some of which are not light fast. If one wants light and stable colors, it is necessary either to go to the more expensive plastics (which may offset whatever saving in finishing cost might be realized otherwise) or to apply a finish over the dark and inexpensive plastic, which, of course, foregoes the saving in finishing which the plastic is supposed to effect. In addition, only a few and mostly the more expensive plastics are suited for continued outdoor exposure or for continuous use in contact with water. It must thus be concluded that the savings securable on the score of reduced finishing cost often are limited and sometimes are non-existent.

They apply chiefly to small to medium size parts for indoor use and then yield the greatest saving only when the cheaper and darker colors or black meet requirements. It is significant that, for such items as small radio cabinets, molding has sometimes been done in dark low-cost colors and the molding has to be sprayed with enamel or lacquer subsequently in lighter colors to meet the demand for these colors. This suggests that an applied finish sometimes is economical even over plastics! The advantages, which the beautifully colored plastics have, applies chiefly to knobs, escutcheons and other (mostly small) decorative parts, a large proportion of which are used in combination with, and to supplement rather than to displace, metals. Witness the fact that, although the automotive industry is the largest consumer of plastics, only a fraction of one percent of the weight of the average passenger car is in plastics (rubber excluded, of course) and the percentage is smaller in most other automotive vehicles.

On the score of availability of plastics in quantities such as to replace metal in any large way, space does not permit of going into much detail. The phenolic plastics, now in widest use, depend, of course, on a supply of phenol which is quite limited and often in demand for other purposes. Although the raw materials for some other plastics are almost unlimited, these are among the more expensive plastics

"Lucite" (one of few plastics suitable for continued use in outdoor exposure) is employed for the transparent parts shown. Remaining parts are die cast in zinc alloy, one of them having a steel insert for added strength.

in some instances and appear hardly likely to become competitive with metals on a large scale. Lignin and some other inexpensive plastics do exist *potentially* in large quantities but their utility on an extensive commercial scale remains to be demonstrated. Moreover, their moldability, when mixed with wood pulp or other fillers presumed to be necessary to give them even moderate strength, appears unlikely to be superior to that of existing plastic with similar fillers, which are suitable only for relatively simple forms and which, as we have seen, are still greatly inferior to metals in strength.

One may speculate that plastics which are both cheaper and stronger than the commoner metals may be discovered, but the chances of this appear distinctly remote, as far as any evidence in hand indicates. Judging from such evidence as is available, it is a safe conclusion that, even if plastics had properties such as to enable them to displace metals on a large scale (which it is clear from the foregoing that they do *not* have), there is at best grave doubt whether they can be made available in quantities sufficient to displace metals on a significant scale.

If, however, one can stretch his imagination to the point of conceiving that plastics *might* have the properties required and *might* become available in quantities sufficient to displace metals in a big way, there would still remain the problem of how to use them on any such scale. Is it conceivable that the thousands of factories equipped and skilled in metal working would junk this equipment and turn to the development of a relatively new skill required to mold plastics on a large scale? Even if the unthinkable occurred, it would take a sizable metal working industry to supply the new equipment needed, to build the molds and to make the supplementary parts needed to fabricate plastics. Almost the whole of modern industry is dependent on metal working and it would require generations to alter such a situation even if we knew how and had the incentive and the disposition to do so.

Were space available, the author could cite numerous specific instances in which efforts to substitute plastics for metals have proved abortive. He could also describe some in which circumstances happened to favor plastics over metals and where plastics have actually displaced metals in a decidedly limited field. There are always borderline cases and those in which rather special sets of conditions lead to compromises and to decisions one way or the other. But enough appears to have been said to make it clear that, although plastics have their good points and are excellent for certain purposes, it is a mistake to suppose that they can take the place of metals on a large scale. Experience indicates that plastics serve well for many small parts for use under conditions such that the properties peculiar to plastics are essential. For large parts, in particular, the safest way is to exercise great caution if molded plastics are to be considered at all in place of metals, for general experience in this direction has not been encouraging.

Plastics in Aircraft

One experience, however, deserves mention, namely, the promising results reported in efforts to use plastics in place of wood or steel in aircraft fabrication. The procedure, as far as revealed, involves impregnating selected wood veneer with (plastic) resin, placing the veneer in several layers in a mold or over a form of wood or concrete, and heating it while under pressure, so that it is cured, much as in molding by ordinary means, except that the work may be done under steam pressure in an autoclave instead of in a press. Resulting structures are reported superior in various respects to those fabricated from duralumin, in the usual way, using numerous rivets and much highly skilled labor. Cost and the time for fabrication are said to be less than for the metal structure. A single large molding, such as half a fuselage, is understood to require some 2 hours to produce, and while this is said to be much less than for the equivalent metal structure, it is much too slow for any ordinary product required in really large quantities at minimum cost.

In short, the comparison is one which happens to favor plastic largely because of its light weight and the strength which the wood imparts. The procedure is economical only as compared with a complex and expensive alternative making use of a high cost material. In other words, the conditions are highly special and would not apply, for example, in automobile body construction, hence they do not affect the general conclusions reached, and especially so since the laminated wood itself is not an inexpensive material by any means.

A Definite Field for Plastics

In conclusion, the author desires to point out again that plastics have a definite and highly important place in the industrial picture. Their primary uses, however, are to supplement and not to displace metals. And since the metal working industry is far and away the largest purchaser of plastics, is it not likely to do the plastics industry no little harm to advocate the substitution of plastics for metals, particularly when, as has been shown above, the feasibility of such a substitution is exceedingly doubtful? To the author it appears to be much wiser to recognize frankly that the two types of materials are basically different and consequently that their uses seldom overlap or become competitive. In uncounted cases the two are used together to the advantage of each and of all concerned.

Beryllium and Some of Its Aluminum Alloys

by C. B. SAWYER and B. KJELLGREN

Brush Beryllium Co., Cleveland

We do not see many worthwhile articles on beryllium and its alloys. There is a great deal of interest in this metal and it is expected that many important uses for it and its alloys will ultimately be developed. The metallurgy of the metal and its alloys is in the early stages of development, but progress is being rapidly made.

We feel that we are fortunate to be able to present this discussion of some of the properties and uses of the pure metal and some of its alloys by men highly competent to present the results of their work.
—The Editors.

FOR A NUMBER OF YEARS the authors and their associates have been developing methods, originating in this country, for the commercial production of relatively pure beryllium metal in solid form, as distinguished from the more usual flake. The purity of the product varies, depending on the care employed. From a guaranteed minimum of 96 per cent it may be produced as high as 99.94 per cent.

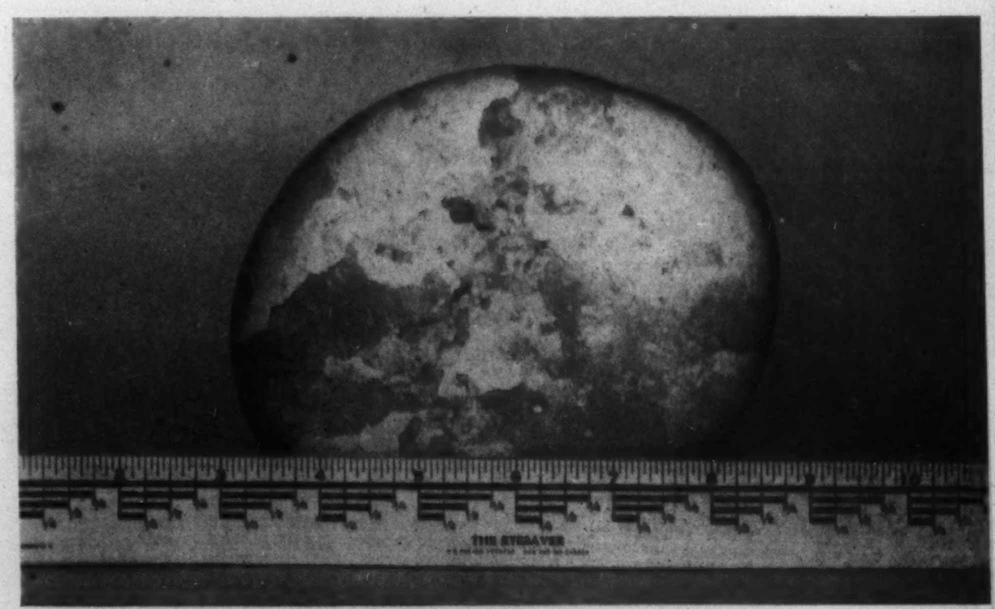
Some Properties of Pure Metal

For purposes of study, a metal was selected containing about 99.5 per cent of beryllium metal, with impurities divided between aluminum, iron, magnesium, carbon and silicon. This metal, as seems to be the case generally with beryllium, tends toward very coarse grains, some of the furnace cooled melts having grains well over an inch in diameter, Fig 1. A preliminary tensile test on a chill cast bar turned into a 3/8-in. screw threaded specimen, gave an ultimate tensile strength of 20,990 lbs. per sq. in. without any measurable elongation. An acoustic determination of the modulus of elasticity by an associated laboratory,[1] gave the result 42.3 × 10^6 lbs. per sq. in. or 29.7 × 10^3 kg. per sq. mm. This is a gratifying confirmation of an earlier determination using 84 per cent beryllium-aluminum.[2]

The computed velocity of sound in beryllium is 12,600 meters per sec. or 41,300 ft. per sec., or about 2½ times as great as that for steel, apparently the next nearest. Preliminary determination of electrical conductivity in the cast condition gave the result of 38.9 per cent that of copper at about 30 deg. C. The 1929 edition of The International Critical Tables gives a resistivity for beryllium corresponding to an electrical conductivity of 17.3 per cent that of copper at 20 deg. C.

The Brinell hardness of this material was 114 at 1500-kg. load, and the impression upon a highly polished surface showed cracks as in Fig. 2 and in Fig. 3 after etching. Both inter- and intra-crystalline fractures are apparent.

Fig. 1. *Furnace cooled plate of beryllium about 1 in. thick, subsequently etched with hydrofluoric acid.*



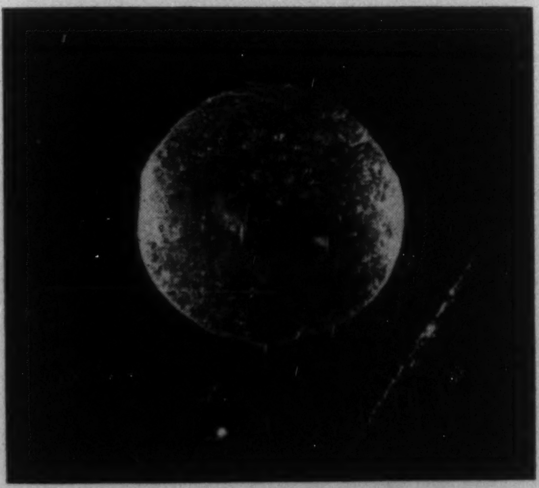


Fig. 2. *Brinell impression at 1500 kg. load on highly polished section of cast beryllium.*

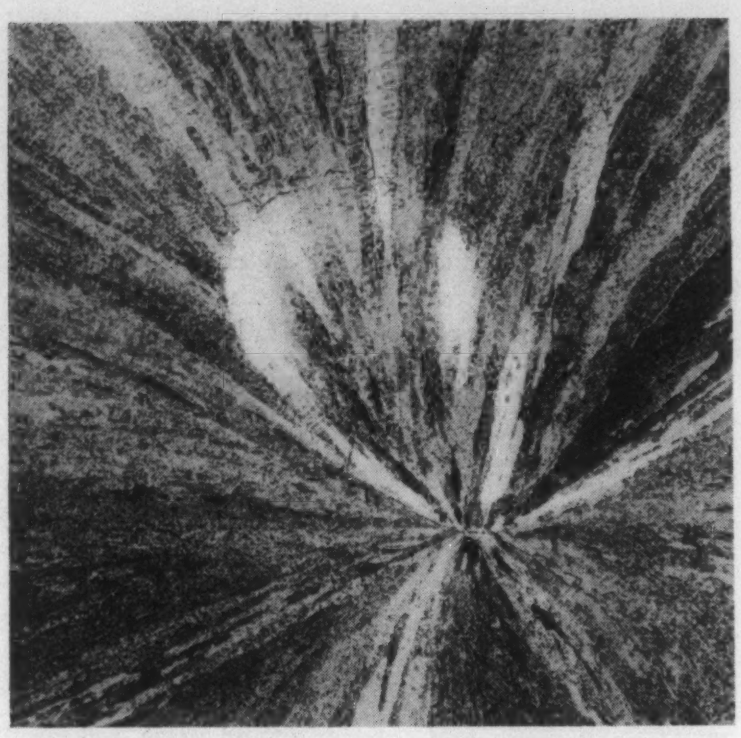


Fig. 3. Same specimen shown in Fig. 2 after etching. Note cracks at top and also below impression.

Under the direction of J. B. Johnson, the Material Division of the War Department at Wright Field ran tests on identical cast material. A direct determination of the modulus of elasticity yielded the figure 42.6 × 10^6 and a tensile strength of 17,000 lbs. per sq. in., without measurable elongation. Brinell hardness number determinations gave 97 at 500 kg., under which load the surface cracked around the impression of the ball.

The expansion coefficient of beryllium was reported by the U. S. Bureau of Standards under date of May 13, 1939, as 0.0000133 per deg. C. at 20 to 200 deg. C., only very slightly higher than that of iron. A simultaneous determination of the mean specific heat between 32 and 100 deg. C. placed it at 0.475 calories per gram per deg. C.

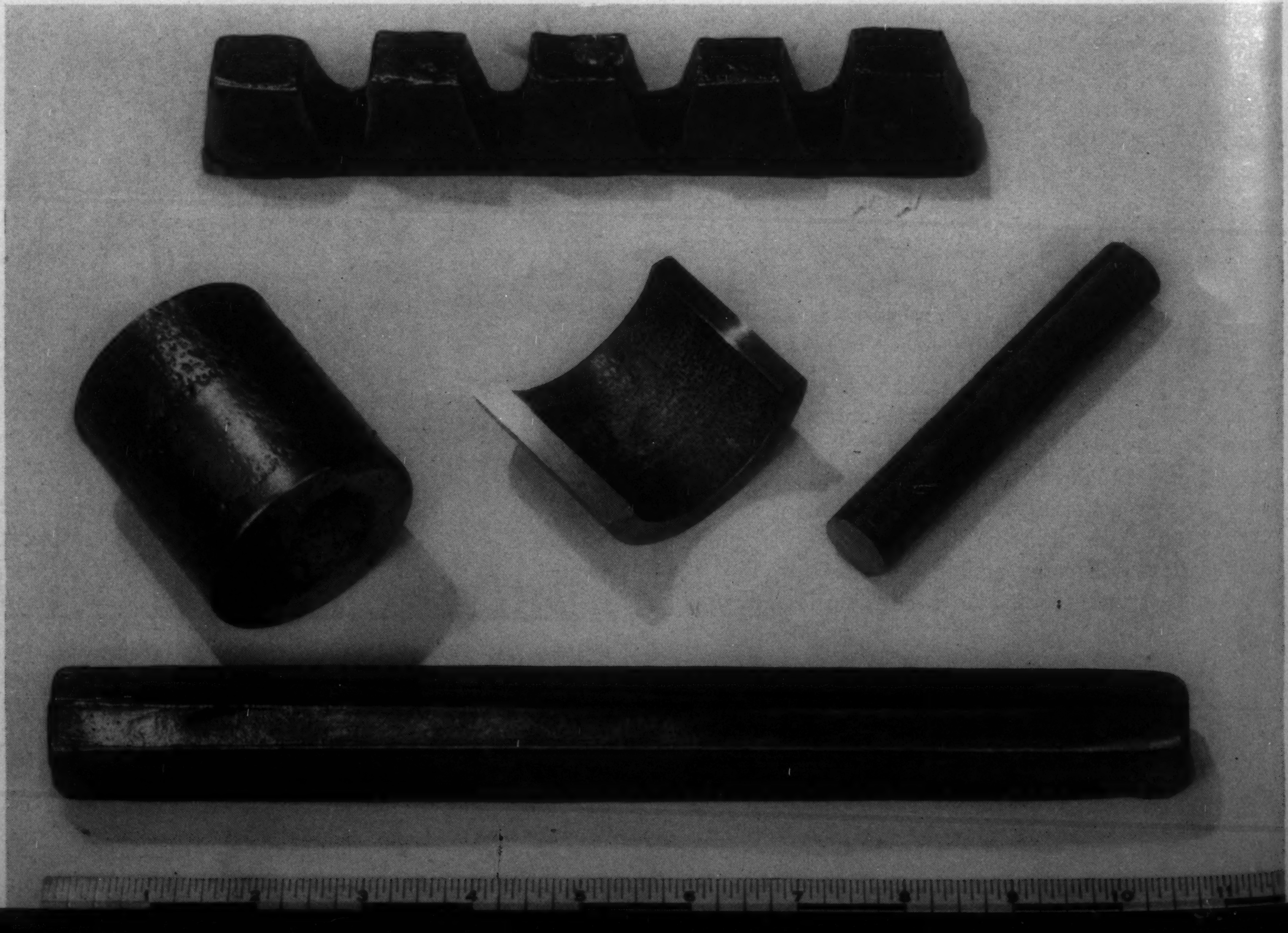
A small sample of 99.5 per cent beryllium was here given a metallographic polish and its total reflectivity in white light determined to lie between 52 and 55 per cent. This compares with about 55 per cent for polished chromium but is notably less than the 80 per cent obtained with polished aluminum. The polished surface of beryllium seems to be permanent. This factor combined with its low density of 1.84, its high elastic modulus and fair electrical (and thermal) conductivity suggests its use for mirrors, both oscillating and stationary.

Casting or Forging the Metal

Beryllium metal despite its high melting point, may be cast readily into simple forms, as shown in photographs in Fig. 4. The extraordinary velocity of sound therein and its apparent permanency suggest numerous acoustic applications, such as high frequency standards.

A ¾-in. cast bar was forged at 900 to 1000 deg. C. into a bar of about 0.36 in. in diameter. Its electrical conductivity, as preliminarily determined early in 1939 in the authors' laboratories, was found to be 42.4 per cent of that of copper, both at 29 deg. C.

Fig. 4. Specimens of cast beryllium.



The physical properties of this forged material were determined and reported by the Aluminum Research Laboratories of the Aluminum Co. of America.[3] Small screw threaded specimens having reduced sections up to 4½ in. in length, were turned from the forged material, in condition both "as forged" and annealed from 1000 deg. C. The following results given in Table I were obtained:

TABLE I—Tests of Forged Beryllium

	As Forged	Annealed at 1000 deg. C. in Hydrogen
Tensile properties		
Ultimate strength, lbs. per sq. in...	29,850	27,000
Yield strength (Offset = 0.2%), lbs. per sq. in..................	......	26,400
Proportional limit, lbs. per sq. in..	9,400	8,700
Elongation in 4 diam., per cent....	0.0	0.0
Reduction of area, per cent........	0.0	0.0
Modulus of elasticity, lbs. per sq. in.	40,000,000	36,800,000
Compressive properties		
Yield strength (Offset = 0.2%), lbs. per sq. in.................	35,300	....
Proportional limit, lbs. per sq. in...	9,200	....
Modulus of elasticity, lbs. per sq. in.	42,000,000	....
Shearing strength	38,600	....
Density	1.844	....
Electrical conductivity, per cent.....	43.1	....

Be-Al Alloys

In April 1938, J. B. Johnson[4] reported tensile tests on sand cast alloy containing 67½ per cent Be, about 30½ per cent Al and balance divided between iron, manganese, copper and silicon. The tensile strength at room temperature, was 13,700 lbs. per sq. in. and elongation given as zero. Using chill cast material prepared under the authors' direction and containing about 28 per cent Al and balance 99.5 per cent Be as used throughout this research, Johnson reported the improved properties given in Table II.

TABLE II

Tensile strength, lbs. per sq. in.....................	25,000
Yield point, lbs. per sq. in.........................	19,000
Elongation in 2 in., per cent.......................	3.0
Modulus of elasticity, lbs. per sq. in................	29,000,000
Brinell hardness number..........................	86
Specific gravity	2.03
Coefficient of expansion per deg. C.................	0.0000151

A photomicrograph of a section of this material as cast is shown in Fig. 5.

The Oesterheld Be-Al diagram is reproduced in the reference[4] above and shows a solid solution of aluminum in beryllium containing up to 8 per cent Al with maximum solubility at 644 deg. C. At the other end of the diagram is an eutectic containing 1.4 per cent beryllium. A cast alloy containing 5.5 per cent Al, balance 94.5 per cent Be, showed a structure as in Fig. 6, with an aluminum phase clearly visible as the eutectic. A cast alloy as above but containing only 3.4 per cent Al, gave the structure shown in Fig. 7. After heating to 650 deg. C. for 6 hrs. and quenching, the structure obtained is shown in Fig. 8, with the eutectic still clearly visible, but formed into globules rather than distributed about the grain boundaries. Figs. 9 and 10 show the structures of an identically prepared pair of specimens but containing only 1.27 per cent Al. Therefore we do not confirm the existence of the solid solution observed by Oesterheld. Archer and Fink[5] in their excellent article on aluminum with small additions of beryllium, have revised Oesterheld's diagram to show an eutectic of 0.87 per cent Be and a solid solution of very small amounts of

Fig. 5. A 28 per cent Al-Be alloy as cast. Al-Be eutectic (0.87 per cent) between beryllium grains etched with 2 per cent hydrofluoric acid. X500.

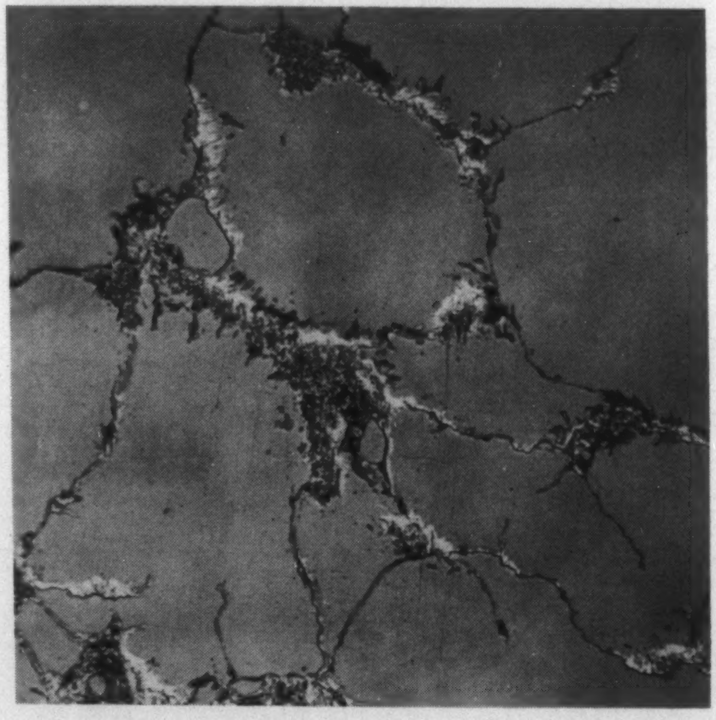
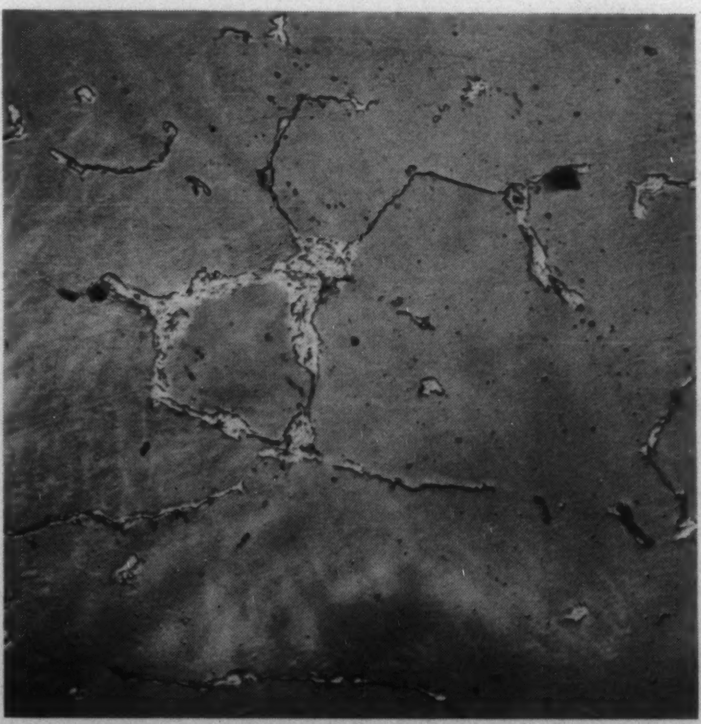
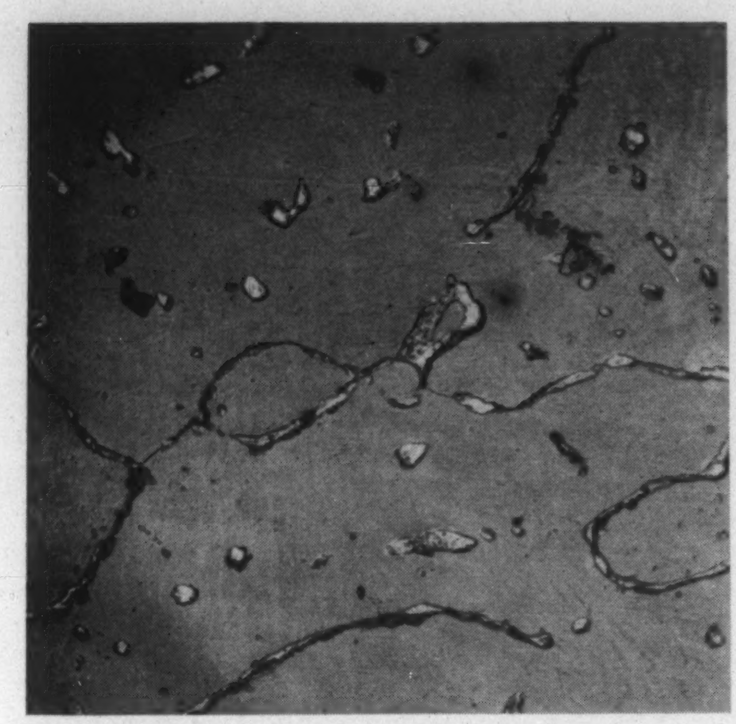


Fig. 6. A 5.5 per cent Al-Be alloy as cast. X500.





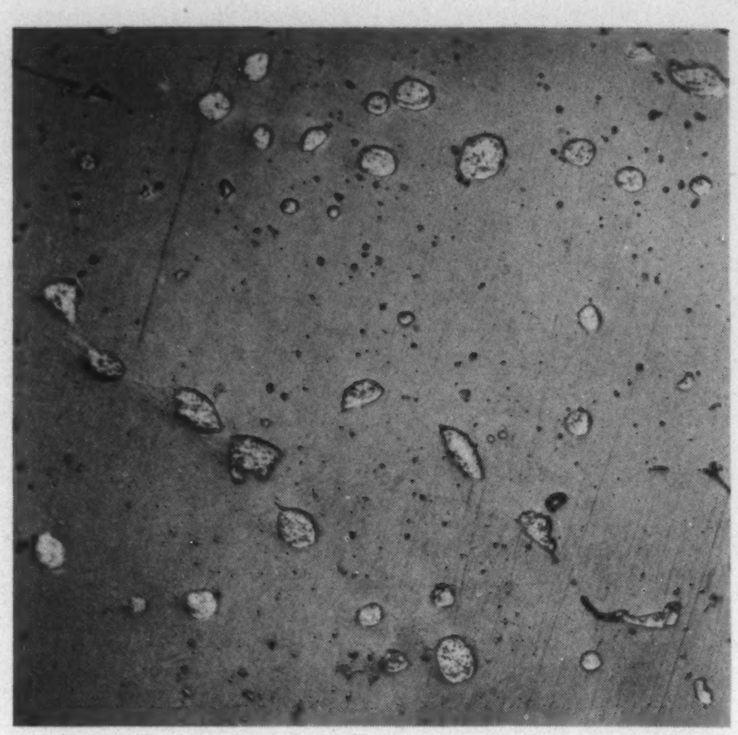


Fig. 7. (Left) A 3.4 per cent Al-Be alloy as cast. X500. Fig. 8. (Right) Same specimen shown in Fig. 7 after heating at 650 deg. C. for 6 hrs. and quenching. X500.

beryllium in aluminum at the aluminum-rich end. Some precipitation hardening was observed by them.

Be-Mg Alloys

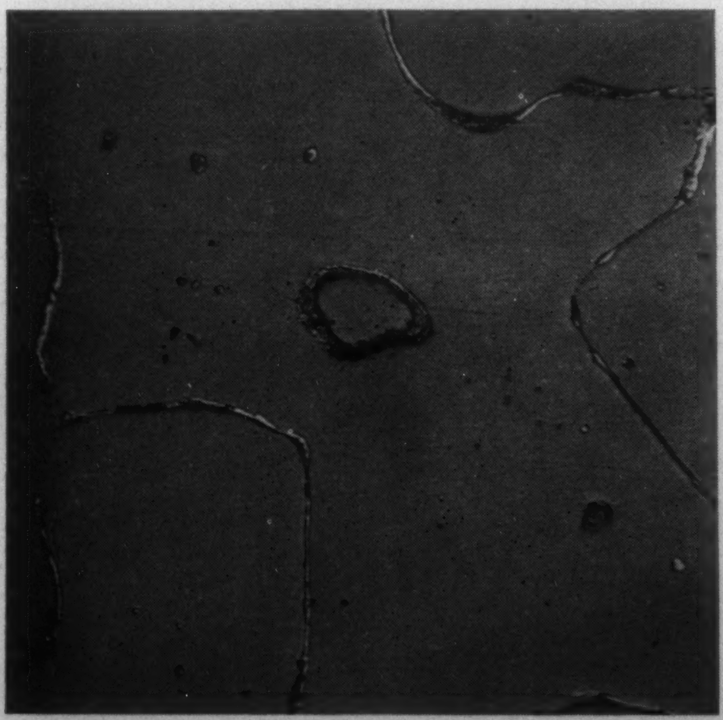
Beryllium can contain magnesium in alloy form up to at least 1 per cent. Beryllium, solidifying in the neighborhood of 1300 deg. C., appears to reject higher percentages of magnesium as a vapor. The boiling point of magnesium is given as 1110 deg. C.

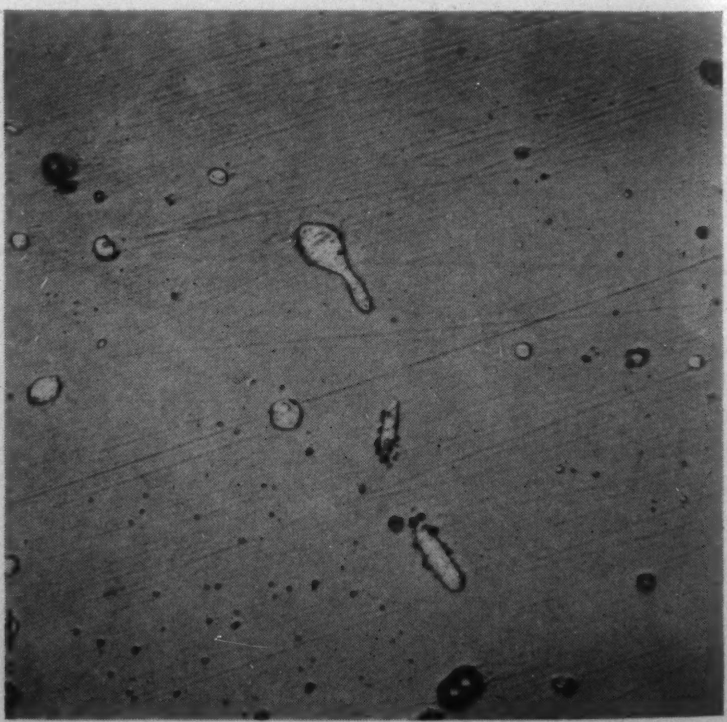
According to Heraeus-Vacuumschmelze A.-G., beryllium is 17 times as penetrable by X-rays as is aluminum, and is not adversely affected by them. It may therefore be utilized as a window to filter out stray or reflected electrons. Fig. 11 shows a group of such windows.

Some Applications

Beryllium metal is used as a target for high voltage

Fig. 9. (Left) A 1.27 per cent Al-Be alloy as cast. X500. Fig. 10. (Right) Same specimen shown in Fig. 9 after heating at 650 deg. C. for 6 hrs. and quenching. X500.





deuteron beams and thus produces neutrons with good efficiency.[6] Good thermal contact is necessary to aid in dissipating heat. Thin films of beryllium may be plated over water-cooled copper targets and because of their adherent nature, offer considerable promise. Also it is possible that castings of pure beryllium might be useful for this purpose where stresses are not out of keeping with the tensile properties given. The relatively high electrical (and thermal) conductivity of beryllium makes this seem attractive. Such castings could be directly cooled internally with water.

Recently L. Losano[7] has made a splendid contribution to the study of pure beryllium. (The authors have available at a price of $10.00 a limited number of typewritten translations with a positive photostat of the original Italian.) In addition to many references given, he has determined a number of the fundamental properties of various beryllium specimens ranging in reported purity from 99.96 per cent to 97.4 per cent Be. Table III is an assembly for comparison (where possible) of his results on pure beryllium with those presented by the authors and with those heretofore commonly accepted. Most of the discrepancies between Losano and the authors tend to disappear when allowance is made for the difference in purity. A notable exception is the electrical conductivity. This table may serve as a reference for beryllium.

Beryllium added to magnesium base alloys containing 8 per cent of aluminum, is said[8,9] to decrease the grain size, hinder oxidation while melting and to increase the resistance to corrosion by sea water. This latter effect, with amounts even so small as 0.005 per cent beryllium, may be extraordinary.[10] Similarly beryllium in amounts from 0.005 to 0.6 per cent may be used for grain refinement in aluminum base alloys.[11,12]

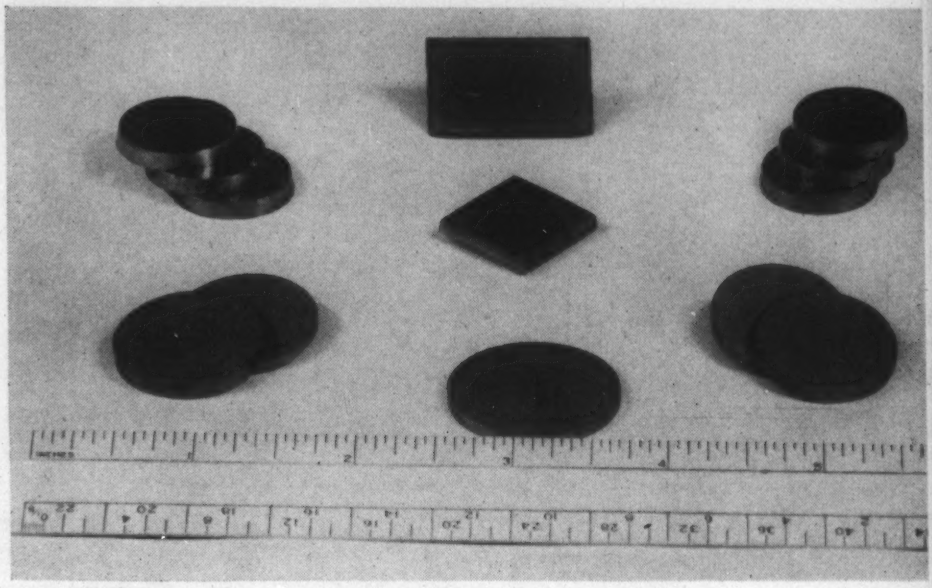


Fig. 11. "Windows" for X-ray tubes.

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[3] Private communication, report by C. R. Buckles, Apr. 14, 1939.

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[6] L. C. Van Atta, A. M. Clogston and H. O. Puls. *Rev. Sci. Inst.*, No. 10, 1939, p. 148.

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[10] B. Wullhorst. *Mitt. Forsch.-Inst. Edelmetalle*, Aug. 1939, pp. 16-25.

[11] French Patent No. 832,821, Oct. 4, 1938. Aluminum Alloys. To the Compagnie de produits chimiques et electrometallurgiques Alais, Froges et Camargue.

[12] British Patent No. 497,241, Dec. 15, 1938. Aluminum Alloys. To Horace C. Hall.

TABLE III.—Physical Constants and Properties of Beryllium

Source	Losano	Sawyer-Kjellgren		1939 ASM Handbook
Purity, per cent	99.96	99.5		......
Atomic weight	......	......		9.02
Atomic number	......	......		4
Density, g. per cm^3	1.816	1.844		1.85
Melting point, deg. C.	1284	......		1285
Boiling point, deg. C 760 mm	......	......		2780
Specific heat, cal/g/°C 30-100 deg. C.	0.516	0.475		0.425
Latent heat of fusion, cal/g	250-275	......		345.5
Linear coefficient of thermal expansion per deg. C 20 to 200	12.4×10^{-6}	13.3×10^{-6}		12.3×10^{-6}
Thermal conductivity, 20 deg. C, Cal./cm^2/cm/°C/sec.	......	......		0.3847
Electrical conductivity, per cent, of copper	13.7	38.9-43.1		9.09
Thermo-electric power (Pt)	—0.16	......		......
Reflectivity (white light) per cent	......	50-55		......
Allotropic change (?) temp. deg. C.	600-700	......		......
Velocity of sound meters per sec.	......	12600		......
Type of crystal lattice at 20 deg. C.	......	......		Hexagonal Close Packed
Lattice constant (A = 10^{-8} cm) 20 deg.	......	......		$a_o = 2.281$ $C_o = 3.577$
Closest approach of atoms, A	......	......		2.22
Hardness (Brinell)	98 (187 Kg load 2.5 mm ball)	97-114 (10 mm ball 500-1500 Kg load)		......
		Cast	Forged and Annealed	
Tensile strength, lbs. per sq. in.	......	17000-21000	27000	......
Yield strength (offset = 0.2%) lbs. per sq. in.	......	......	26400	......
Proportional limit, lbs. per sq. in.	......	......	8700	......
Elong. in 4 dia.	......	0.0	0.0	......
Modulus of elasticity, lbs. per sq. in.	......	42.6×10^{6}	36.8×10^{6}	42.7×10^{6}

Prehistoric Metals

by HENRY D. HIBBARD

Plainfield, N. J.

The author of this article is an honored dean of the American steel industry and we are always glad to publish his writings. This interesting recital of the early beginnings of the production of metals, the reduction of some ores and the preparation of articles of gold, copper, tin, bronze and so on, is based on a careful study of the subject and on visits to the British and other museums by the author.—The Editors.

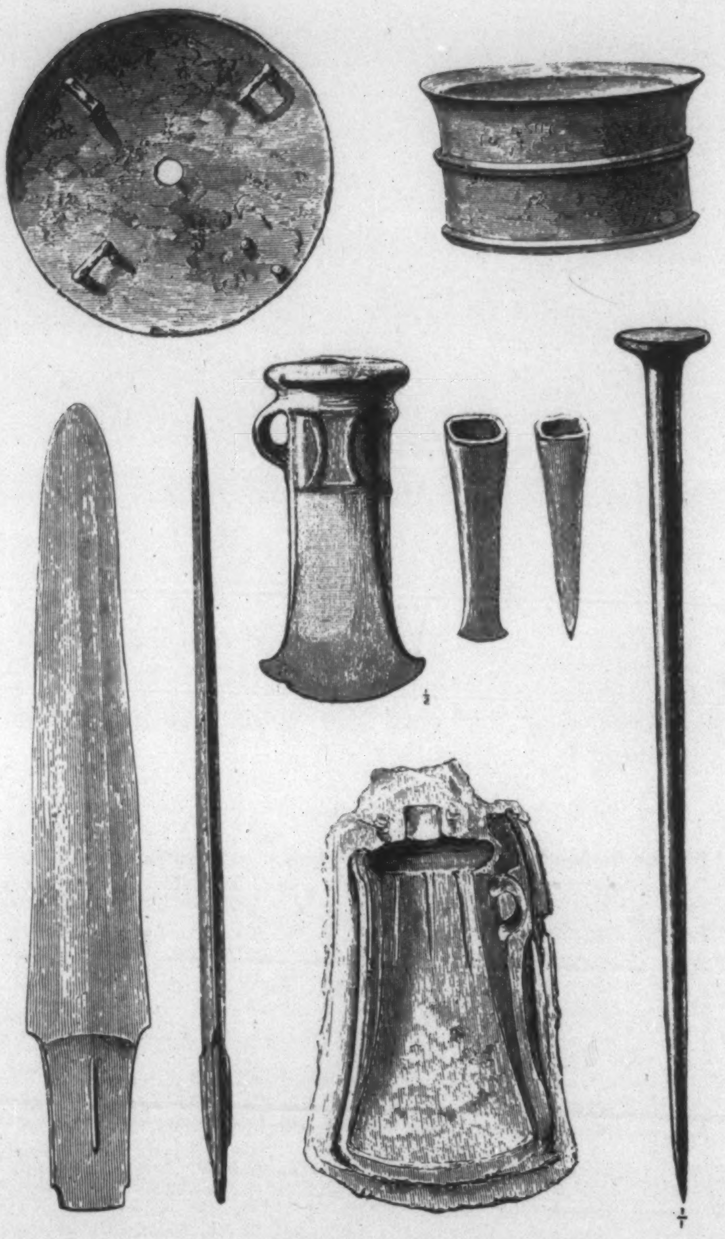


Fig. 1. Cast axes, swords, dishes and so on of bronze from Heathery Burn Cave. Taken from an illustration in "A Guide to the Antiquities of the Bronze Age," published by the British Museum.

NEOLITHIC MAN HAD ONLY WOOD, stone, hide, horn and bone of which to make his tools, weapons and implements. When he first employed metal for some of these purposes, the occasion must have been to him of transcendent importance, not exceeded in interest, perhaps, by any that have followed. When and how it was done are alike unknown. Whether or not men then had written language, they left no record and the only direct evidence we have bearing on the subject is that offered by prehistoric articles of metal, and by stones and bones which may have been fashioned by metallic tools. Nevertheless, in spite of the scarcity of such evidence, it is of interest to try and trace man's beginning and early progress in the metallurgic art.

Prehistoric objects of metal which have survived to the present time have, without exception, been concealed from men during the interim, usually by being buried under earth or water. To that circumstance their preservation was due.

The first metal to be used was, undoubtedly, one of those which occurred native, that is, in the metallic state in nature; either gold, copper or iron, (meteoric) whose relative frequency was in the order given. The use of a native metal was a comparatively simple procedure, calling for no great inventive faculty, though the softening of metals by heat may not have been known at first. The great step ahead was the discovery in and obtaining of a metal from its ore.

In prehistoric times, as now, the chief agent for winning and working metals was fire, that is, heat. The use of fire by man was one of his earliest as well as his greatest achievements in his conquest of nature, which he then started and is now pursuing with ever greater and swifter strides.

The Neolithic Age

In the Neolithic or New Stone Age, the arts of the Old Stone Age were preserved and developed. That of fashioning stones—usually flints—into tools, knives and points of spears and arrows, reached a high degree of perfection. Until recently this has been considered to be a lost art; but now some men claim to have rediscovered it, and to be able to duplicate any of the products in that line of that Age. The articles they make are, of course, merely to show their skill. It is of interest to note here that the saw may be considered as having been invented before the knife, as the blades of flint or other stone, even sharp obsidian flakes, could have cut only soft, weak material by pressure alone. To cut any harder or stronger substance, such as wood or meat, the so-called knife would have to be drawn back and forth across it as in sawing.

The first use of metal may have coincided with the end of the Neolithic Age.

Gold

Gold was probably the first metal to be put to use. Even if copper and iron were known, gold was the most widely disseminated native metal, was the easiest to work, and the only one of the three that could be heated and even melted without oxidation. Being more plentiful than the other two, it was for that reason of less value measured by the standards of the times. Probably the oldest objects of metal fashioned by man now surviving are of gold. These are few in number, as nearly all old gold objects found by man have been reworked for other purposes.

The first gold to be found and used was nuggets and "dust" in alluvial or placer deposits. The rock which originally contained it was disintegrated by the sun's heat, by frost, wind and water, and most of it carried away, the gold particles lagging behind because of their greater weight. The dust, of course, required to be melted in order to be made into pieces large enough to be of use, and doing that was man's first metallurgical operation. This melting, and indeed all metallurgical fusions in prehistoric times, was probably done in clay pots or crucibles; for the potter's art doubtless antedated every other followed by man, except, perhaps, the shaping of wood and stones.

But gold was observed in rock "in place" as well as in placers, and efforts to get it out constituted the first mining operations. Without steel tools, and with fire and stones as principal aids, progress was slow indeed, but the value of the metal to those who had only neolithic materials of which to make implements, was great, and justified the effort.

Copper

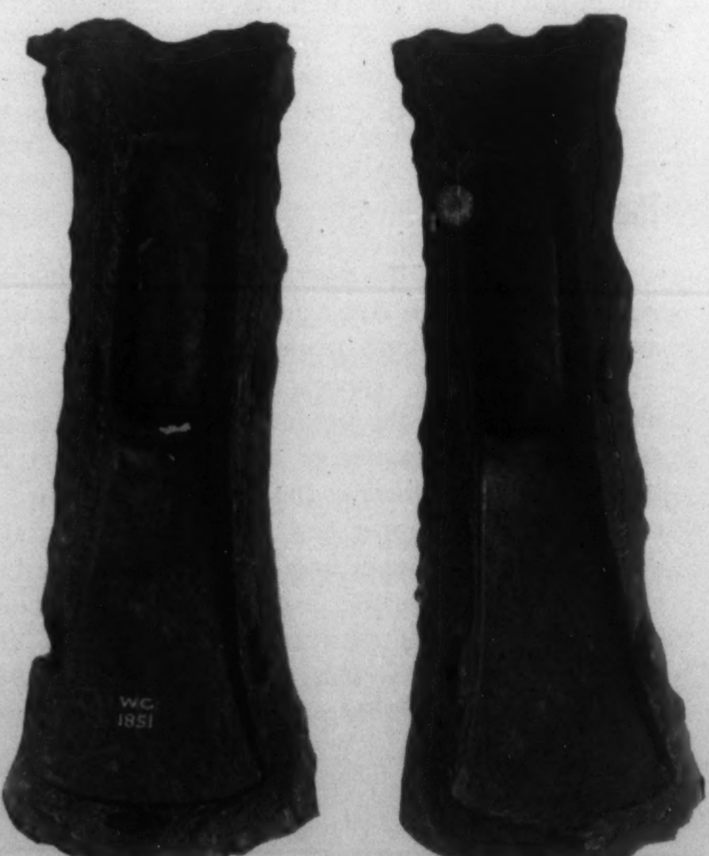
It is possible, but unlikely, that copper, which occurs native in a few localities, was the first metal to be worked and used by man. But the abundant native copper of the Lake Superior district in Michigan, which aborigines used as they could, did not lead to the production of copper from its ores by the use of fire or otherwise. Small pieces they cut and shaped with stones to make utensils, points of weapons and ornaments, while from the large masses they were only able to detach small slivers by long continued pounding with stones. Whether or not the half-civilized men of the Neolithic Age would have learned from these pieces of copper, if they had them, how to produce metal from its ores, no one may say.

Gold mining naturally brought to view other associated minerals, one of the commonest of which was the yellow sulphide of iron and copper, known as chalcopyrite. The color, weight and metallic lustre of this mineral, as well as its occasional propinquity to gold, led to the conjecture that it contained gold, and to trials to see if gold could be extracted from it. Such trials naturally included heating and melting the mineral in various ways, and repeated attempts at last yielded copper but not gold.

The affinity of sulphur for iron in the ore must have proved a hindrance, and many treatments were found necessary to oxidize the iron and bring out the copper. Then, from extended experience it appeared that gentle heating, while exposed to the air, near to but below redness, so changed the mineral that the metal was obtained with fewer meltings —two or three perhaps. That is, roasting, which changed the sulphide largely to oxide, preceding smelting, simplified and hastened the operation.

Though copper has not the ability of gold to resist corrosive agents and action, it was for many purposes as good as or even better than gold because it was lighter and stronger. Having both gold and copper, the next step ahead was for some unknown genius to melt them together in varying propor-

Fig. 2. Bronze mold in which one type of axe or hatchet heads were poured.



tions, when some of the resulting alloys were found to be harder and stronger than either metal alone, therefore more suitable for many purposes.

The production of copper, which was so different from gold, and, unless they had seen some native copper, wholly unfamiliar to its producers, raised the question as to what was in other metallic appearing minerals found in delving into the earth for gold. It was, of course, noticed that gold and chalcopyrite were both much heavier than the rock which contained them. The query, whether or not other minerals, heavier than rock, also contained metal was natural and trials followed to find out.

Tin

The mineral cassiterite or tinstone is heavy, having a specific gravity around 7. It consists chiefly of oxide of tin, and is sometimes called "streamtin" from its occurrence in the beds of some brooks and rivers. It was found in washing some gravels or sands in search for gold, as in the Malay peninsula. The production of tin may have preceded that of copper. Though its ore does not look like a metal, the way it acted, like gold, in washing may have raised the question as to what was in it that made it so heavy. Trials to find out naturally included heating in a pot, such as was used in melting gold dust. Charcoal for reduction of the oxide may have gotten in by accident, but more likely a layer of hot ignited coals was laid on the ore in the pot to conserve heat. When some tin was thereby reduced to the metallic form, the rest was easy, and the proper amount of carbon required for complete reduction was soon determined. Whether this was the actual procedure or not, with the experience gained, in smelting copper, if it was produced first, the production of tin from its oxide presented no great difficulties.

Thus copper and tin, the ingredients of bronze, were on hand to serve as the basis of the Bronze Age.

The Bronze Age

This Age covers the period between the Neolithic Age and the Iron Age, or the dawn of history, during which mankind made great progress toward civilization. Their greatest metallurgical achievement was, perhaps, the production and use of bronze as evidenced by samples of their work in that line still existing. Following the experience gained in melting together copper and gold, it was natural to do likewise with copper and tin. With one part tin to 8 or 9 of copper, the resulting alloy was notably harder and stronger than either metal alone, and, therefore, more serviceable in weapons and cutting tools as well as for other purposes. It was also more easily fusible than copper. The making and using of bronze then went forward.

The principal way of putting metal into desired shapes was to melt it and pour it, that is, cast it, into prepared molds, usually of sand. This was the founder's art which attained a fair degree of efficiency, though on a small scale compared with present day operations. In the foundry, as in producing the metal, it was melted in clay pots. Cast axes and swords are the most important things of bronze now surviving from this Age, but dishes and smaller articles, including ornaments, needles, awls, etc., have been found. Fig. 1 shows a few.

One notable feature, and perhaps the most instructive as to the progress made in the founder's art in the Bronze Age, are the bronze molds then sometimes used instead of sand molds for casting axe or hatchet heads. These molds were durable so that they could be used for many casts and were therefore economical. Fig. 2 shows one of these. Each mold consists of two pieces, which are mates, and weigh together perhaps 3 or 4 lbs. They are quite nicely fitted to each other with a groove or mortice along the joint on one part which receives a ridge or tenon to match on the other.

Numbers of these molds, found in western Europe, that is England, France, Italy and Spain, are in the museums of those countries. The British Museum in London has four complete molds and several halves. Similar ways of using metallic molds have been reinvented from time to time ever since, its acme being found in modern diecasting. Stone molds for casting sword-blades, dating likewise probably from the Bronze Age have also been found and are now in the museums.

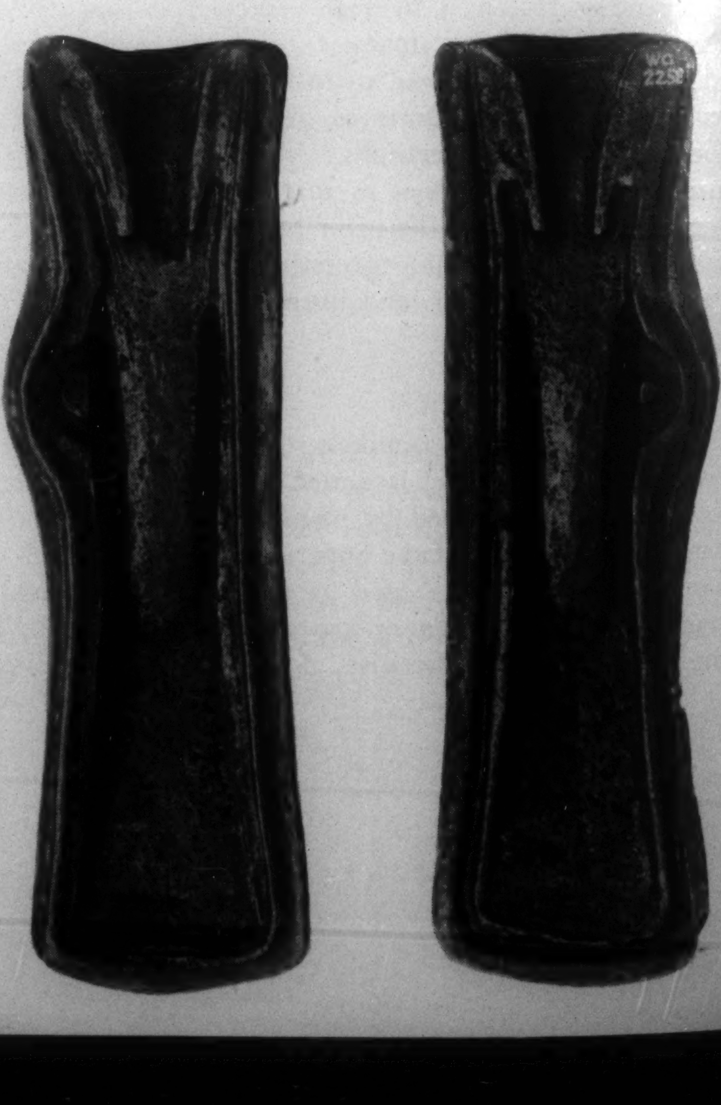


Fig. 3. Another type of bronze mold in which hatchet heads were poured.

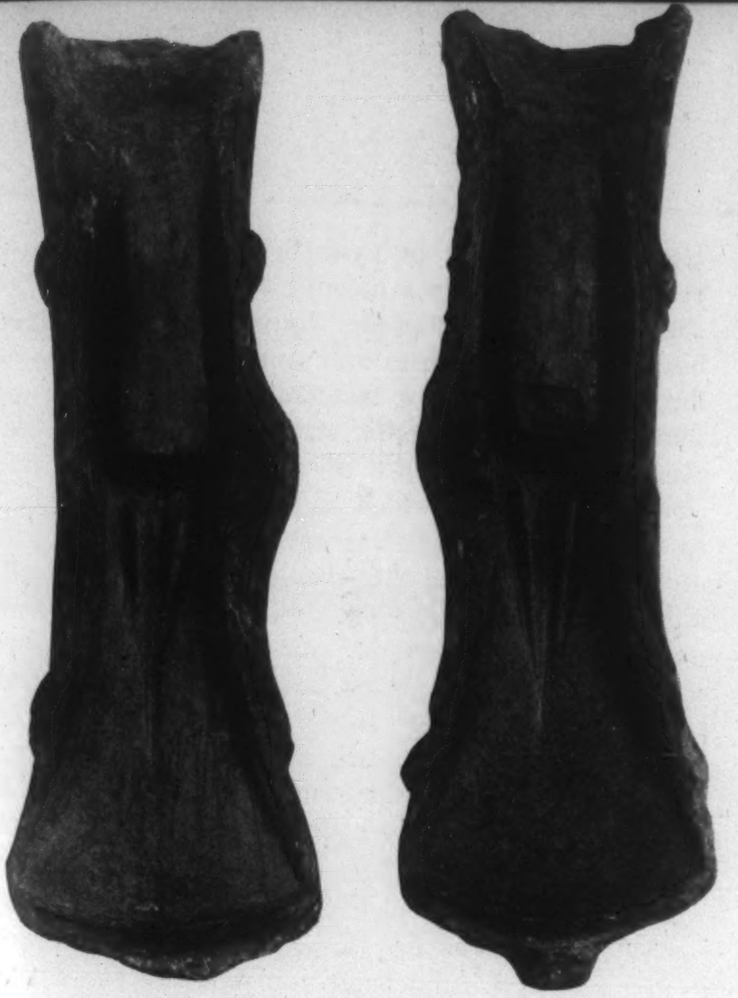


Fig. 4. Still another style of hatchet or axe head mold of bronze.

The handle of a bronze axe was usually a piece, nearly 2 ft. long, of the trunk of a small tree, having a stout branch, which latter was cut off at a length suitable for holding the axe-head, or about 3 in. There were several ways by which the head was attached. In one a socket or recess was cored out in the back of the head into which the branch was fitted. In another, a sort of socket was formed on the near side of the head by projecting flanges which were bent around the branch. In a third way, the back of the axe-head was made with an I section. The branch was split to allow the web of the I to enter, while the sides of the branch fitted and filled the spaces on the sides of the web flanges. Still another style was more simple, the head being tapered and passed through a slot in the handle, which was merely a straight stick, with the wider part of the head, bearing the cutting edge, in front.

These constructions gave a suitable angle between the head and the handle. On some heads a small perforated lug was located on the near side for attaching it to the handle to prevent loss. A thong of leather was passed through the perforation and around the handle. In later times, perhaps in the Iron Age, the bronze head of the axe was provided, in the way now common, with a large hole running through it in which a straight handle was fitted. The similarity in design of all axe-heads seems to show that the same axe was used indiscriminately for war or domestic purposes as occasion arose. Bronze axe-heads are not heavy, most of them weighing between 1 and 2 lbs. As they were used by one hand it would perhaps be more correct to call them hatchets rather than axes.

Brass

The names bronze and brass sometimes meant the same thing in ancient literature. The production of real brass came later than that of bronze. Its discovery is not so explainable as that of bronze for the reason that one of its constituents, zinc, was not known to the ancients as a separate metal. Until modern times the alloy was made by heating together copper, roasted zinc carbonate and charcoal. Zinc was thereby reduced which alloyed at once with the copper to form brass. This method had the drawback that the proportion of each metal in the alloy so produced varied greatly. Relatively accurate control of composition only came when the two metals were melted together in the eighteenth century. In the Bible, Tubal Cain is mentioned as teaching the working of brass and iron some 5,000 years ago; but in that case "brass" probably meant bronze.

Iron

Viewing the stone cutting of the ancient Egyptians, one naturally concludes that they had fairly efficient steel tools for the purpose, even though no examples have survived. Such tools were, of course, costly and precious, and were therefore carefully guarded, so as to be seldom lost, much as tools of gold would be now. Then, if lost, they would have been completely oxidized if exposed in almost any environment in the elapsed centuries. The oxide, if found in the open, probably would not have excited notice.

At working wood the Egyptians were not good as is shown by their wooden coffins now existing. Their tools for this, even if of steel, were crude and inferior. They lacked sharp cutting edges, but were enough better than the flint and obsidian tools of the Neolithic Age to wholly displace them. But the wood surfaces, after being shaped with cutting tools, required to be smoothed, which evidently was done by rubbing with some abrasive material, presumably either stone or sand.

The Bronze Age antedated the Iron Age, as is well known. Meteorites containing metallic iron may have been, and probably were, found, but they gave no clue pointing to the production of iron from its ores. That came about in another way or ways.

The most probable method was perhaps the production of steel in crucibles by reduction, in a charcoal fire, of magnetic oxide of iron by charcoal mixed with it. The winning of tin ore by washing, and the presence of metal in it, raised the point that perhaps magnetite, which was also a heavy black mineral contained a metal. It is, and was then, usually present in gold-bearing sand or gravel, and remains behind with the gold when the dirt is carried away by the water in the washing operation.

Trials to get a metal from this black sand were probably made soon after tin was produced but while the smelting of tin was comparatively easy, that of iron by such means as were then at hand, presented all but insuperable difficulties. Iron is reduced at low red heat from its oxide to the metallic state by contact with suitable amounts of carbon or carbon monoxide—the latter being a gas—but that is only a part of the problem. Iron so reduced would be a loose spongy mass, quite useless. To get it into a useful state it must, after reduction, be either melted or welded into a compact mass. If it contains 1 per cent of combined carbon it will melt at 1440 deg. C., while to weld carbonless iron it must be heated to about 1420 deg. C., and then consolidated and welded by hammering while hot. These temperatures are attainable only by fires urged by a forced blast of air. Either a chimney or a blower would be needed, and neither was known to prehistoric man.

Based on their knowledge and experience with metals, the ancients probably held that any metal, to be put into useful form, must be melted. So the founder's art preceded the smith's. Welding of metals may not have been known for a long time after melting them had become common.

Perhaps only after failures for generations to get melted iron, that is, steel, someone was lucky enough to hit upon the proportion of carbon to magnetite in the crucible to reduce the metal and also to give it around 1 per cent carbon; then at the same time to raise the temperature of the charge to about 1450 deg. C. through being aided perhaps by a gale of warm dry air to blow his fire. The first crucibles used were probably small to favor attainment of the high heat required, also they were relatively long and narrow so as to give the charge when reduced, melted and then solidified, the form of a short thick bar. Enough steel was made in one charge, perhaps 2 or 3 lbs., to make one tool or weapon. It was allowed to freeze in the crucible, and shaped later by heating and hammering. To cast it into an ingot would have been far more difficult, chiefly because it would not have the necessary excess temperature above fusion.

How to harden and temper steel may have been learned much later. Perhaps someone, to hasten the cooling of a steel ingot, hot from the crucible, plunged it into water and found, to his astonishment, that such action made it both hard and brittle. Manifestly the cure of such unwanted hardness was to heat it again. The variations of properties gained by varying such treatment were then learned by experience.

Another, and ~~perhaps equally~~ plausible chain of events, may have led to the production of iron, and so, indirectly, of steel. Copper, as noted, may have been won from chalcopyrite in trials to get gold. Then trials may have followed to get copper from iron sulphide or pyrite which is also a heavy yellow mineral with a metallic lustre, and far more abundant than chalcopyrite. Repeated and prolonged heatings, both roastings and smeltings, on the same lot of mineral, at last resulted in the reduction of some iron to the metallic state. That being accomplished, the resemblance of some limonites or bog iron ores, to pyrite which had been heated, exposed to air, as in roasting, was naturally noticed. Trials of these ores showed that they contained iron, welding was discovered and the production of iron from its oxide was established. Its occurrence in pyrite was of no further interest. Assuming this method to be the one actually followed, the conversion of iron into steel by the ancients is not so easy to imagine. It may have come only after the production of iron rich in carbon in deep fires but that is, to say the least, unlikely.

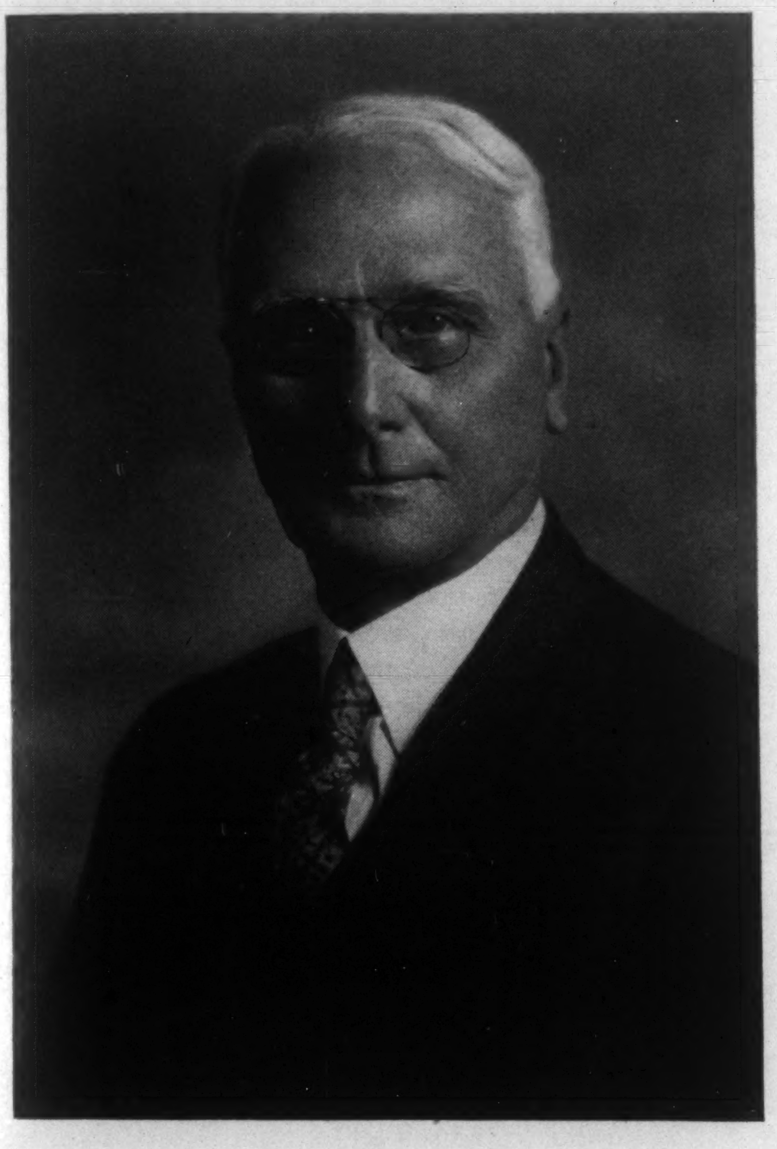
The speculation which has been advanced that iron may have been first accidentally produced from its oxide heated in an open fire, seems to the writer most improbable. Iron is far more likely to be oxidized than reduced in such a case. For such reduction a deep long-continued fire would be required such as could hardly have been made accidentally and there would have been no reason for making one intentionally. The production of iron in a deep fire was a later development. It survives to this day in some remote rural localities in India and Africa, and perhaps elsewhere. The spongy mass so produced is called a bloom or loup. The production of iron, whatever the method, was achieved only after copper, either alone, or in alloys, had long been in use, perhaps for thousands of years.

Other Metals

Having gold, copper, tin and iron, men naturally examined and tried all the minerals they found which were notably heavy or had a metallic lustre. Lead, silver, antimony and mercury were in turn obtained from their sulphides. The first production of all these metals was prehistoric.

To recapitulate, the steps in the production of prehistoric metals were:—

1—Native gold nuggets or dust. Melting to make large pieces.
2—Gold in rock, sometimes with chalcopyrite.
3—Trials to produce gold from chalcopyrite.
4—Production of copper from chalcopyrite.
5—Copper-gold alloys.
6—Production of tin from cassiterite.
7—Copper-tin alloys. Bronze.
8—Production of brass from copper and zinc ores.
9—Trials to produce copper from pyrite.
10—Production of iron from pyrite.
11—Production of iron from oxide.
12—Production of lead, silver, antimony and mercury from sulphides.



Dr. Edwin Fitch Northrup

died April 29, 1940, after 74 years of a life full of service as a scientist, service of particular value to the metallurgical industry. Professors of physics who appreciably and directly affect and improve large sections of industry within their lifetimes are rare, but Northrup was such a man, because, though he had all the knowledge of the high-brow professor, he was always vitally interested in putting physics to work. Indeed, though he taught a year at the Univ. of Baltimore and 10 years at Princeton, he was in industry before and after the Princeton interlude.

His first industrial work was in the development of a multiplex printing telegraph system, then his attention became focussed upon instruments, which resulted in the formation of the Leeds and Northrup Co. Some 30 years ago Dr. G. H. Clamer was interested in fractional distillation of metals at reduced pressure, for which purpose he looked into the "pinch effect" furnace which Dr. Carl Hering was trying to develop. The physics of the pinch effect was not understood, and Dr. Northrup was called in for counsel. He applied his mathematics to the case and straightened out the theory.

From this association grew the connection by which Dr. Northrup aided in the development, for the various Ajax companies of which Dr. Clamer is the moving spirit, of the Ajax Wyatt and the Ajax Northrup induction furnaces, as well as of high frequency induction hardening. No metallurgist needs to be reminded of the value of induction heating as a metallurgical tool, or of the new and valuable products made possible by its use in research, and in commercial production.

Not only did Northrup have the intellectual background necessary for such work, but he had the personality that inspired confidence in his ability to work out his ideas in a practical fashion, so that "patient money" was available to back him.

In spite of his busy life, he took out over 100 patents and solved innumerable difficulties, and despite the honors (such as the Longstreth, Cresson and Acheson medals, and recognition just before his death as one of the "Modern Pioneers") that naturally came his way as his reputation grew, both as a scientist and industrialist, he was a most unassuming individual, always with time for his friends and for younger men who came to him for information and guidance.

Also, he always had time for his pointers and for tramping the open with them, both for training and for quail. One of the high spots of the old "Section Q" meetings of the Electrochemical Society was a talk by Northrup on "The Electrochemistry of Dogs." One could divert him from technical conversation about furnaces, to a topic really nearer his heart, by asking about "Pyko," the pointer that Mrs. Northrup used as messenger to summon Dr. Northrup to meals. His book "Zero to Eighty," dealing with rocket cars and other ways of utilizing the principles of physics, bore the alias "A. Pseudoman" as author, but even without Northrup's preface one would have known who wrote it, from the frequent reference to pointers.

His associates tell us that at New Year's 1940, he hung a sign in his office reading: "Neophobia—this word means dread of the new. It's a bad disease. Hope no Ajax person has it. E.F.N."

High Hardenability and Toughness in Carbon and Low Alloy Steels

by JEROME STRAUSS

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THE METALLURGICAL LITERATURE of the last two decades has been replete with references to the differences in properties displayed by heats of carbon and low-alloy steels having, within quite narrow limits, equal amounts of the elements ordinarily determined in the chemical laboratory and forming a highly important part of most specifications. These differences, displayed principally following thermal treatment, have resulted in the attribution to steels of a vaguely defined characteristic called, perhaps for the want of a more definitive term, body or personality or timbre. The use of these words has afforded qualitative expression for a property admittedly unknown but functioning somehow to alter the reaction of the steel during either drastic or mild cooling from above the transformation range for the purpose of producing an increase in hardness over that of the annealed state.

Three Important Developments

The beginning of our understanding, or perhaps better, more intimate acquaintance with these differences between steels not expressed in the ordinary chemical analysis resulted from the classical work of McQuaid and Ehn which called attention to the properties resulting from variations in grain size; at the same time these investigations endeavored to account for the variations. The ultimate result was the creation of a general consciousness of the physicochemical behavior of the thermally-hardenable steels, a broad attack on methods of control and the provision of a new specification requirement as an aid in securing more uniform products.

A second high spot in the unfolding of the story came from Shepherd's work on the hardening of steels and his classification on the basis of the depth of penetration (P) of effective hardening and the fineness (F) of grain of hardened and fractured specimens. This P-F classification is in a measure quantitative and has found wide use, especially in carbon and low-alloy tool steels.

The third measuring stick is of quite recent origin and represents a refinement in the determination of the penetration of hardness. Not that this characteristic has not been subject to considerable study by many investigators, but the simplification developed by Jominy and Boegehold has made possible more widespread use of such determinations and permitted incorporation of the method into specifications without requiring costly inspection and delays.

Many other investigators have of course contributed materially to our knowledge of the properties of steels disclosed by studies of this character. It is desired to point out here that, as a result of this accumulation of data over the two decades, information and tools are now at hand that permit of a much more intelligent method of preparing specifications that, if wisely handled, will secure to the user steels most suited to modern mass-production methods while permitting the steelmaker the necessary exercise of his judgment and facilities with some degree of freedom.

It is significant that the origination of this knowledge and of the means of applying it is largely an American accomplishment.

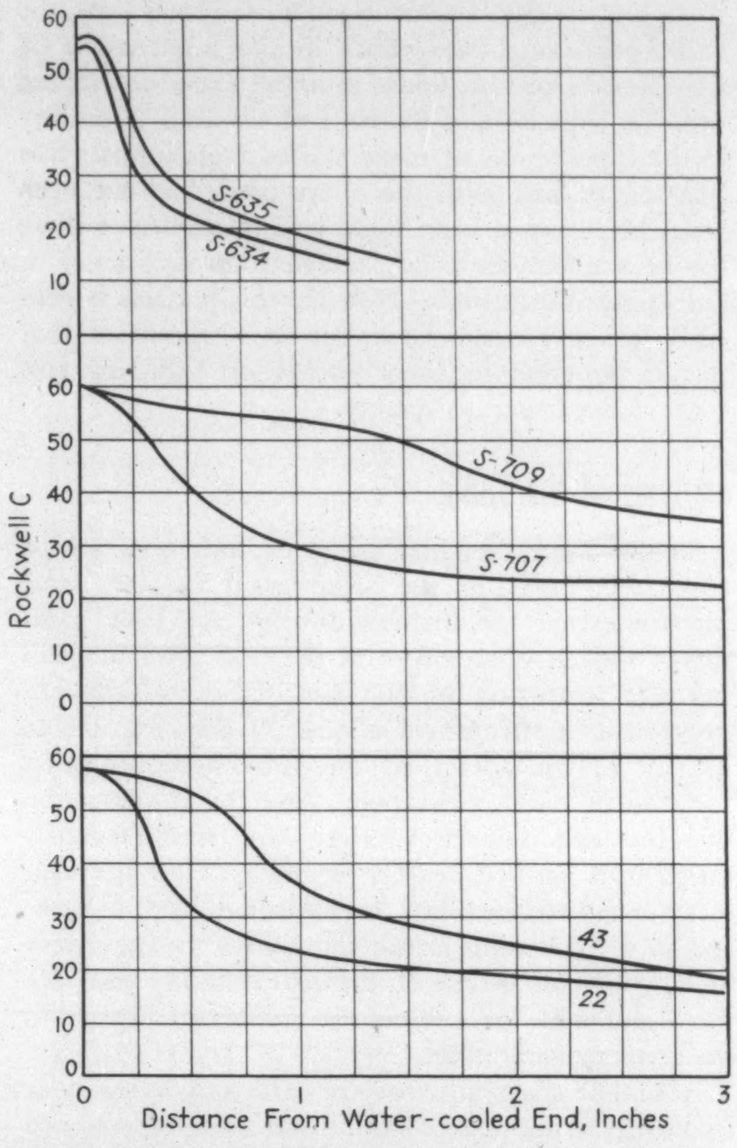
Grain Size and Hardness

Returning to the subject of manufacture, the steelmaker has at his disposal a choice of many practices wherewith to meet the new requirements. Obviously, these concern various phases of his operations and in each instance must be coordinated with the known functioning of equipment of a given plant in order to yield the objective sought. The factors that control grain size and the nature and distribution of inclusions are well understood. The behavior of the alloying elements has also been exhaustively studied and well summarized. Some control over hardenability has resulted from grain-size control methods plus the use of alloying elements. In general, it has been learned that fine grain size in a given steel, with its desirable toughness, has been accompanied by shallow hardening and vice versa, coarse grain by deeper hardening with less toughness, and that, for a fine-grained deep-hardening steel possessing the mechanical properties accompanying both conditions, the use of grain refining practices or alloys plus rather substantial additions of certain alloying elements has been necessary.

A New Group of Alloys

A further advance seems now to have been recorded by the development of a means of securing high hardenability not only in coarse-grained but also in fine-grained steels without the heretofore required large amounts of alloying elements. A group of alloys has been produced that secure this result with only very small additions (of the order of hundredths of one per cent) in the final stages of steelmaking, yielding products of exceptional uniformity and furthermore providing high toughness at high hardness without large alloying additions. (These alloys are commercially designated by the name of "Grainal"—Reg. U. S. Patent Office.)

The results obtained with one of these alloys are reported in this article. This one member of the group is a ferroalloy containing approximately 25 per cent vanadium, 15 per cent titanium and 10 per cent aluminum and is usually added in such amounts that less than 0.10 per cent vanadium and often as little as 0.02 per cent vanadium is introduced into the melt; the most frequently used addition has been in the range of 2 to 5 lbs. of alloy per ton of steel. The tremendous change in the response to heat treatment of carbon and low-alloy steels due to this small addition is evident from the accompanying Table. Many of the tests recorded have been



Hardenability of Plain and Grainal-Treated Steels.

Table of Mechanical Properties and Hardenability of Plain and Grainal-Treated Steels

Serial Number	Chemical Composition					Heat Treatment	Yield Point, Lbs. per Sq. In.	Tensile Strength, Lbs. per Sq. In.	Elong., Per Cent in 2 In.	Red. of Area, Per Cent	Izod (aver.) Ft. Lbs.	Hardenability (Jominy Method) Depth from Quenched End to R_c 50, In.
	C	Mn	Si	Cr	V							
S-634	0.40	0.66	0.14	...	....*	1525° F.W.Q.+600° Air	97,500	129,800	18.0	53.3	48.7	0.10
S-634						1525° F.W.Q.+950° Air	89,650	116,150	22.5	61.3	90.2	...
S-635	0.42	0.62	0.22	...	0.03	1525° F.W.Q.+600° Air	147,475	182,400	15.2	56.0	23.2	0.17
S-635						1525° F.W.Q.+950° Air	105,325	127,725	20.2	64.8	83.7	...
23	0.38	0.91	0.24	...	....*	1550° F.O.Q.+550° Air	93,100	124,700	21.5	64.8	...	...
26	0.38	0.91	0.24	...	0.029	1550° F.O.Q.+550° Air	212,200	257,300	13.5	46.9	...	...
23						1550° F.W.Q.+550° Air	165,500	215,420	13.0	41.3	...	...
26						1550° F.W.Q.+550° Air	210,130	239,950	14.0	56.7	...	...
S-729	0.56	0.92	0.17	...	....*	1525° F.O.Q.+450° Air	110,200	158,700	12.5	38.5	4.5	0.17
S-730	0.56	0.93	0.16	...	0.028	1525° F.O.Q.+450° Air	258,200	301,500	10.0	38.5	5.7	0.23
S-731	0.56	0.92	0.17	...	0.050	1525° F.O.Q.+450° Air	261,250	302,700	9.0	36.0	**6.7**	0.33
S-729						1500° F.W.Q.+450° Air	267,750	295,700	2.0	3.9	...	...
S-730						1500° F.W.Q.+450° Air	272,650	303,000	6.0	22.3	...	...
S-731						1500° F.W.Q.+450° Air	276,350	306,200	8.5	34.7	...	...
S-707	0.41	1.83	0.23	...	....*	1500° F.O.Q.+450° Air	196,000	252,250	11.0	37.5	6.2	0.33
S-709	0.42	1.78	0.24	...	0.048	1500° F.O.Q.+450° Air	231,750	269,500	12.5	49.8	**18.5**	1.50
22	0.41	0.93	0.27	0.58	....*	1550° F.O.Q.+450° Air	220,150	255,700	6.0	23.7	6.0	0.24
01	0.41	0.92	0.28	0.58	0.028	1550° F.O.Q.+450° Air	233,500	270,500	10.0	39.1	**12.7**	0.41
43	0.42	0.92	0.28	0.58	0.063	1550° F.O.Q.+450° Air	235,750	275,200	12.5	49.2	**15.2**	0.62
22						1575° F.O.Q.+900° Air	106,700	132,000	18.5	60.7	72.5	...
01						1575° F.O.Q.+900° Air	134,950	153,250	16.0	59.3	61.0	...
43						1575° F.O.Q.+900° Air	164,350	171,850	14.0	54.7	52.2	...

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* Plain steel, *not* Grainal-treated.

made on bars rolled from ingots in the same heat, the additions having been made in the ingot mold by introduction of the finely crushed alloy distributed over the large part of the time of teeming. Contrary to the expectations of many skilled metallurgists this practice, at least with the alloys used, has not been productive of any irregularity and in particular there has been no evidence of damage from additional or redistributed inclusions. Not that this practice is generally to be recommended but it is significant that it can be done in ingot molds of sufficient size without detriment to quality.

Analysis of the Table

In the Table, the first group of four tests are of two steels made in the same plant by the same practice except for the addition of the alloy mentioned above. Comparison of the tests after quenching and tempering to 600 deg. F. shows the improvement in strength of almost 35 per cent due to the use of the alloy. At the same hardness (first and fourth tests) yield point, elongation, reduction of area and impact strength are simultaneously raised to a marked degree. There is a 70 per cent increase in hardenability, as measured by the penetration of hardening in the Jominy test to the extent of R_c 50. Full details of the hardenability tests for these and also the subsequent steels are shown in the accompanying chart.

A similar sharp increase in hardening capacity is recorded for the other S.A.E. 1040 steel, represented by the second group of four tests; these are from a split heat. In this case the treated steel oil quenched and tempered is both stronger and more ductile than the untreated steel after water quenching, the tempering conditions being the same for both.

The third group (six tests) are from a heat of S.A.E. 1055 in which ingots were treated with two different amounts of the alloy. The doubling of the hardenability is significant as is also the doubling of tensile strength in the oil quenched state with simultaneous increase in impact resistance and likewise the increase in ductility in the tension test shown by the bars quenched in water. Thus water-hardening carbon steels are converted into oil-hardening steels by this small alloy addition; the importance of this fact in parts of irregular section in respect to cracking and warping is obvious.

In the application of the alloy to medium manganese steels such as S.A.E. 1340 the results have been striking. Reference to the next group of two tests will show the almost five-fold increase in hardenability, a three-fold improvement in impact strength and a substantial increase in all the values of the tension test.

The behavior of the manganese-chromium steel is similar to that of the other steels mentioned. This is again mold treatment of successive ingots in the same heat. All of the tests in this table, it should be noted, were pre-machined to within 0.02 to 0.03 in. grinding allowance per side and then heat-treated, except in the case of the last group tempered at 900 deg. F. which were treated as 1-in. rounds.

Work has been carried out on other steels of the carbon and low-alloy types, and also with other alloys, resulting in improvement of properties similar to those described. It is hoped in subsequent publications to include some of these data. The cause of the changes observed is still not entirely clear although several possible explanations have been advanced. This brief note records only the facts in order that those interested in the improvement of constructional steels may be informed of the progress made.

A Couple of Chuckles

"Sandurgist"

New subscribers to METALS AND ALLOYS are asked to give their occupations—engineer, plant executive, metallurgist, metallurgical engineer and so on. We had one recently who classified himself as a "Sandurgist" in a foundry. He evidently specializes in sand conditioning and so forth.

If "metallurgist," why not "sandurgist," though we do not find that word in the dictionary.—E. F. C.

Tin in Ball Bearings

From "Uncle Sam's Weak Spots" by B. Smith in *American Magazine*, February, 1940, pages 21, 128-130:

"Tin is also necessary in solder, bronze, and *ball*-bearing metals." (Italics ours)—H.W.G.

Hydrogen, Flakes and Shatter Cracks

A Correlated Abstract · Part II

Impurities in Steel and Anomalous Hydrogen Behavior

That hydrogen reacts with impurities in the steel, especially oxide impurities, to form rupturing pressures of water vapor and other gaseous products has often been postulated.[17, 70, 128] Perhaps too much importance has been attached to the possibility that fissuring is produced by this type of reaction, for none of the ordinary gaseous products of such reactions has a greater molecular volume or a greater energy of formation than does molecular hydrogen. Therefore, an impurity may be most effective merely by acting as a discontinuity in the path of diffusing hydrogen so that pressures may develop in the manner already discussed. Bodenstein[60] investigated the reactivity of atomic hydrogen as it left the inside surface of a steel tube and found that the gas did react with oxygen to form water. However, he found no reaction with bromine, chlorine or sulphur, and only a slight reaction with nitrogen to form ammonia. He assumed that the atoms recombined so instantaneously after leaving the iron lattice that, of all the possible reactions, the recombination of the atoms to form molecular hydrogen was the most probable.

Nevertheless, the formation of reaction products other than molecular hydrogen has two important aspects. First, if the reaction takes place within cavities or discontinuities in the steel, fissuring caused by the occluded gas will show abnormal relations with temperature. That is, at temperatures where molecular hydrogen in cavities would normally dissociate in contact with the steel and diffuse away to reduce the local pressure, the presence of an impurity may cause another reaction yielding a more stable gaseous product. In non-ferrous metallurgy there is the common instance where hydrogen reacts with copper oxide to cause embrittlement, or "hydrogen sickness."[191] Baukloh and Retzlaff[189] emphasize that the greater stability of some of these reaction products may well account for defects in steel that appear at higher temperatures. Besides the reactions with oxygen and nitrogen just mentioned,[158, 189] reactions with sulphur[158] and carbon[111] have been definitely established. For other reactions there is disputed evidence.

Secondly, if the reactants are in solution in the steel, or are molecularly dispersed, the energy of the reaction will act to retain hydrogen in excess of its normal solubility. Steel in the elastic state undoubtedly holds most of its impurities in nonequilibrium conditions, which predicate the existence of remanent chemical forces. Also, the fact that hydrogen dissolves atomically suggests that the dissolved gas may be unusually active chemically, and that reactions with dissolved impurities in the steel may therefore be strongly favored. It is well known that elements which form stable carbides in steel are most active in suppressing the deleterious effects of hydrogen.[135, 150, 160, 174, 222, 223]

Both of these types of reaction will change the behavior of hydrogen in steel from that of hydrogen in iron. Nevertheless, investigations frequently appear wherein some defect in steel might well be explained as the result of hydrogen activity except that analysis of the steel has shown insufficient hydrogen present, or the writer emphasizes that the steel had previously been annealed in the best manner of the classical researches on the removal of hydrogen from iron. From the foregoing discussion of solubility, diffusibility and occlusion, it should be evident that accurate analysis for hydrogen, even in pure iron, is exceedingly difficult; and hydrogen in steel should not be expected to show the same behavior as hydrogen in iron.

When the necessary distinctions are made between iron and steel as a retainer of hydrogen, many experimental results, which at first appear contradictory, may show relation. For example, although

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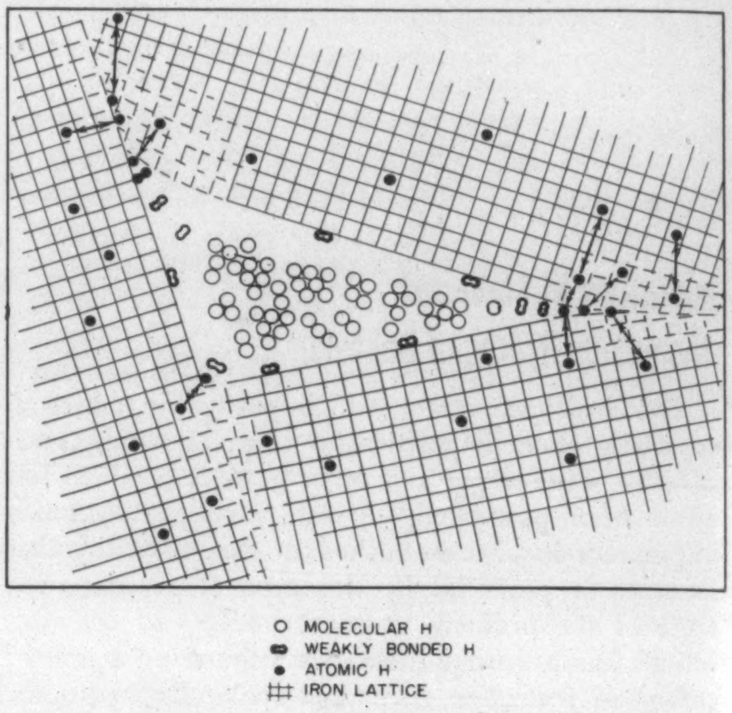
pure iron almost completely relinquishes its hydrogen at 400 deg. C., Körber and Ploum[108] found that a 0.97 per cent C steel evolved only traces of hydrogen at 400 deg., and that evolution first began at higher temperatures. Large amounts of methane were found in the extracted gas. Rapatz[50] has shown that steel evolves hydrogen during drilling even after the steel has been annealed. Yajima,[208] analyzing steel ingots, states that evolution of hydrogen begins at 500 deg. C. and is rapid at 900 deg. C. With iron, simple solution and diffusion are the controlling factors, and Sieverts[18] has shown that at 400 deg. C. equilibrium is rapidly attained; with steel, porosity affords occlusion of gas that is notably insoluble at moderate temperatures, and foreign elements in the steel may markedly alter the apparent solubility. On the other hand, diffusion of atomic hydrogen is sufficiently rapid at ordinary temperatures so that, even in the analysis of pure iron, the specimen must be analyzed immediately after loading with hydrogen or a significant portion of the gas will be lost (refer ahead to Fig. 4). The ordinary analysis of steel, therefore, measures for the most part only the hydrogen occluded within the steel as molecular hydrogen or as hydrogen reaction products, which in many cases is probably the portion remaining after the damage has been done. Hydrogen analyses of iron and steel should therefore be accepted only with extreme caution.

The reaction of hydrogen with carbon to form methane[111, 115, 116, 138-140, 159-161, 189-192, 211-214] has interesting aspects other than those already discussed. Cementite is known to be unstable,[111] and the C-H bond is strong at ordinary temperatures. There should be a reaction, then, between dissolved hydrogen and carbon, depending only in degree upon the chemical state of the carbon. Such a view is encouraged by the fact that the diffusibility of hydrogen in steel decreases, and the solubility increases, with increasing carbon content.[115, 116, 158] Thus, the precipitation pressure of hydrogen in steel, as opposed to iron, may be relieved to a large extent during cooling by the collapse of four volumes of atomic hydrogen into perhaps one volume of a methane-like structure at carbon nuclei, and escape at discontinuities is rendered unnecessary.

An action of this type would explain the poor response of some defective steels to standard annealing and aging. Hydrogen would be retained in unexpected quantities, appearing during subsequent treatment, perhaps, to aggravate some type of defect. As methane decomposes at moderate temperatures,[111] slight heating would destroy the iron-hydrogen-carbon structure with the formation of two volumes of molecular hydrogen or four volumes of atomic hydrogen from the one volume of methane. Together with the volume increase due to temperature rise, this action might account for some phenomenon similar to blue-brittleness.

Fig. 3. Diagrammatic representation of reversible occlusion of hydrogen in the disjunction between crystalline units.



"Reversible Occlusion" and Embrittlement

Three mechanisms have so far been discussed whereby hydrogen may be retained in steel at ordinary temperatures: (1) A negligible amount of atomic hydrogen may be held in interstitial solid solution; (2) great quantities and high pressures of molecular hydrogen, or compounds of hydrogen, may be occluded in cavities, inclusions and grain boundaries; and (3) excess atomic hydrogen that would normally be forced to leave the metal lattice may be withheld by the formation of bonds with dissolved, or highly dispersed, impurities in the steel—especially carbon.

The formation of fissures is based upon the process of occlusion, mechanism (2), whose highly irreversible nature accounts for the great pressures of gas that obtain. That occlusion of molecular hydrogen in steel is highly irreversible is attested by the pressures of this gas that have been obtained experimentally; by the observation that, with a constant supply of atomic hydrogen, these pressures increase at a rate that is undiminished as the pressure increases;[92] and by the fact that steel containers are used to store hydrogen.

(Passage of molecular hydrogen through steel only occurs at disputed pressures of 4000, 6000 and 9000 atmospheres (See T. C. Poulter and L. Uffelman "The Penetration of Hydrogen Through Steel at Four Thousand Atmospheres" *Physics 3*, 1932, 147-148) the least of which is great enough to indicate that there is no measurable diffusion at low temperatures without rupture.)

As will be shown shortly, hydrogen trapped in steel under a pressure of 30 atmospheres during experimentation at Battelle Memorial Institute remained in the steel at that pressure for four months, at the end of which period the cylinder was drilled to permit the gas to escape. Re-solution of the gas is only appreciable at temperatures above the gamma to alpha transformation.

Embrittlement, on the other hand, has been popularly explained as a result of hydride formation, although some investigators believe that, like fissuring, embrittlement is due to occlusion of hydrogen in grain boundaries and ultra-microscopic cracks. Embrittlement is quite reversible at low temperatures, so must be largely due to mechanism (1); and the rapid, beneficial effects of aging and low-temperature annealing are therefore principally functions of diffusibility. However, it is well known that fissuring defects respond to low temperature treatment in exactly the same manner as does embrittlement. In view of the fact that the formation of gas under high pressures depends upon the relative inability of this gas to diffuse out of cavities at low temperatures, an explanation of this unexpected response is necessary. For such an explanation the three mechanisms just discussed appear inadequate.

There is therefore apparently a fourth mechanism—a mechanism which, under certain conditions, combines solution and occlusion, increasing the solubility of molecularly occluded gas and conferring some reversibility upon the otherwise highly irreversible (at low temperatures) trapping phenomenon. Enlightening insight is given to such a mechanism by the recent excellent work of Moore and Smith on hydrogen in iron[236] and in nickel,[201] and Smith and Derge,[134] and Moore,[235] on hydrogen in palladium. These authors have shown conclusively that great quantities of hydrogen collect in "rifts" within the metallic lattice, and that this hydrogen is strongly ionized. These so-called "rifts", they state, are closely associated with slip planes and mis-matched lattices of adjacent crystals.

The observations and the excellent data supplied by these investigators now make it possible to explain the contradiction just noted. In addition, there is afforded good evidence of a concept of embrittlement of steel by hydrogen that is free from some objections attending the hydride theory of embrittlement—a concept which in turn offers interesting evidence of the mosaic structure in metals proposed by Zwicky, Smekal, Lennard-Jones, Dehlinger, and others. Thus, in the same manner that steel-rupturing pressures of gas are produced by precipitation of molecular hydrogen in cavities in the steel, so should high pressures of gas be developed within the rifts and lattice disjunctions, discussed by Moore and his collaborators. The extremely small size and the great dispersion of such discontinuities would provide a general stress within the steel, identified as embrittlement, instead of the previously discussed type of high local stress that leads to observable fissuring.

Many observations strengthen this belief that the embrittlement of steel by hydrogen is largely a function of separation of the fine-structure by high pressures of molecular hydrogen. In the first place, evidence from several different sources indicates that the structure of metals is a mosaic, or block structure, and density measurements have shown that the specific volume of a metal is increased by cold-working. This increase in the volume can only be due to an increase in the volume of the submicroscopic pore space,[75] which action would provide greater internal free-space in which hydrogen might collect. It has long been known that the quantity of hydrogen absorbed by steel increases directly with the degree of cold-working; and well-annealed steel shows remarkable resistance to embrittlement by hydrogen,[124] undoubtedly due to the diminished size and number of internal disjunctions, in contrast to the extreme vulnerability of cold-worked steel. Bardenheuer and Ploum[124] have shown that solder penetrates steel that has been loaded with hydrogen in exactly the same way that it penetrates steel that has been cold-worked. This observation strongly suggests that the function of hydrogen in embrittlement is to force open rifts and deform the fine-structure.

Körber and Ploum[108] heated coiled iron springs in hydrogen and found that they became permanently deformed. Baukloh and Stromburg[191] show that the deep-drawing properties are never fully recovered after the steel has been pickled. Bardenheuer and Ploum[123, 188] present extensive evidence that steel treated with hydrogen never fully regains any of its original properties.

[R. K. Reber ("The Effect of Nascent Hydrogen on the Magnetic Properties of Iron" *Physics*, 1934, 5, 297-301) observed that the volume of a steel ring increased rapidly during electrolysis, reaching a threshold value when the plastic deformation was complete and the back-pressure was sufficient to prevent further absorption. The condition of the steel was unaltered by annealing at temperatures too low to permit recrystallization.]

Observations of this type, which are plentiful, show that something that is submicroscopic has been permanently displaced coincidentally with the embrittling action. It is reasonable to expect that such a displacement of the fine-structure by high pressures of gas would result in some permanent deformation, with consequent change in the properties of the steel. On the other hand, it is inconceivable that the strain which, according to the hydride theory, must be caused by one hydrogen atom, located in one interstice of a block of perhaps a thousand iron atoms, is not immediately removed with the removal of the hydrogen atom.

Straining of the fine-structure, then, may well be the mechanism by which hydrogen embrittles steel.

Such a picture of embrittlement seems more satisfactory for several reasons than the loose, commonly accepted conception of hydride formation. Evidence of hydride formation in palladium, and tantalum, is unmistakable, but in regard to iron the term "hydride" is apparently figurative, and the implications of the term are open to question. Palladium actually absorbs the stoichiometric quantities of hydrogen necessary for compound formation, as does tantalum, but iron saturated with hydrogen even at the melting point contains only one hydrogen atom in about two thousand iron atoms, and at ordinary temperatures the ratio is less than one in two million. Compounds are identified by their characteristic crystal structure. For hydrogen and iron none has been found. Furthermore, the solubility of hydrogen in palladium, and in tantalum, decreases with increasing temperature, which conforms to ordinary dissociation of compounds; whereas the solubility of hydrogen in iron increases with increasing temperature. Perhaps an iron hydride forms endothermically, but surface reactions do not indicate this, as they are highly exothermic. Numerous other objections to this widely argued postulate make welcome an alternative conception.

To propose that the embrittlement of steel by hydrogen is caused by high pressures of this gas precipitating at the disjunction of neighboring crystalline units in a mosaic structure, it is necessary to explain also for embrittlement the contradiction between data and theory that has been pointed out for the case of fissuring. Specifically, how does the highly compressed hydrogen, previously described as being almost irreversibly precipitated at low temperatures, escape during aging or low temperature annealing? The fact that most defects attributable to hydrogen in steel disappear similarly during low temperature treatment requires that some distinction be drawn between the transient high pressures operating in these phenomena and the permanent pressures already discussed. Of course, volume difference alone must account for a great difference in the rate of pressure relief, assuming a constant rate of escape, but there may be another factor.

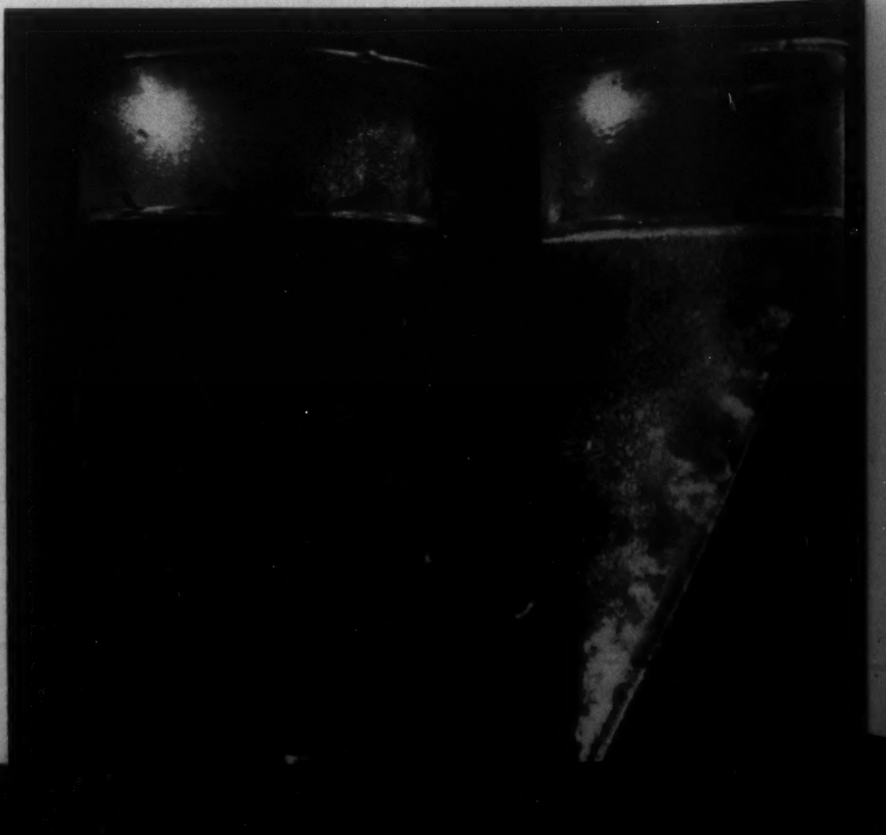
The observation that "rift-occluded" hydrogen is strongly ionized provides the desired distinction, for it shows that the hydrogen collecting in these rifts is dissociated to some extent in contrast to the great lack of dissociation, for example, in tank hydrogen. That is, the electrical properties of steel are changed, when loading with hydrogen shows evidence of "rift-occlusion;" whereas hydrogen occluded molecularly in larger cavities exerts little or no effect. The mechanism and the effects of this partial dissociation of occluded hydrogen may be explained by the following argument.

Briefly, gases do not dissolve in metals unless they are first adsorbed on the metallic surface.[207] Adsorption is a surface phenomenon ascribable to the asymmetry of the force field of the surface atoms. That is, while interior atoms are uniformly surrounded by other atoms, to which they are held, surface atoms are not so surrounded, and the uncompensated forces often act strongly to attract extraneous atoms. In the case of a visible cavity in the steel, the curvature of the surface from the standpoint of an atom is negligible, and the amount of hydrogen that will diffuse back into the steel is a function of ordinary adsorptive forces acting on a flat surface. For molecular hydrogen at ordinary temperatures this is quite negligible, as has been mentioned. In the case of disjunctions in the fine-structure, however, the free space is bounded by a finite number of metal atoms, and the sharp angle made by converging rows of these atoms must markedly alter the adsorbing forces.

(C. R. Bloomquist and R. S. Shutt ("Fine Particle Suspensions in Organic Liquids" to be published shortly in *Industrial and Engineering Chemistry*) show that the converging surfaces of minute glass spheres so strongly alter the adsorbing forces of the spheres that surface films of water collapse and concentrate at the point of convergence.)

Considering the diagram in Fig. 3, it is evident that the state of the hydrogen in such a discontinuity should vary from the one extreme of insoluble molecular hydrogen in the center of the rift, through stages of increased weakening of the H-H bond by adsorptive forces, to actual atomic solution in the lattice beyond the apex of the angle of disjunction. Because some atomic hydrogen in this case is present in the free-space as well as in the lattice, the process of diffusion and occlusion is no longer irreversible, and embrittlement stress, likewise stresses leading to the intracrystalline flake and similar defects, may be relieved by aging or by low temperature annealing. The occlusion of hydrogen in large cavities is highly irreversible because there is negligible dissociation and the partial pressure of the diffusible atomic hydrogen

Fig. 4A. Evolution of hydrogen from a 3/16-in. rod 30 sec. after immersing in hot water. Left: untreated. Right: pickled for 10 min. in H_2SO_4.



is almost zero. Irregular, tiny cavities, such as those caused by micro-shrinkage in the dendritic interstices during freezing, may provide similar re-entrant angles sufficiently acute to establish reversibility.

This dissociation and ionization effectively reduces and regulates the equilibrium pressure (P_{H_2}) according to the mass action expression, and both the magnitude and the behavior of the deleterious effects due to hydrogen in steel must thereby be largely dependent upon the nature of the discontinuity in which the gas collects. Because (P_{H_2}) for ordinary hydrogen is such a tremendously high value, high pressures must still obtain even though the gas is strongly dissociated.

In conclusion, it might be pointed out that X-ray examination[122, 191] of iron-hydrogen alloys has revealed distortion of the iron lattice, but that the diffraction lines are always diffuse. This diffuseness is due to the superposition of lines of parameter values that vary from those of pure iron to those of iron with maximum distortion. Referring again to Figure 3, it is evident that there will be a concentration gradient around each rift, and such diffuseness would therefore be expected.

Experimental Observations

To substantiate theory with some practical observations, the following simple experiments were performed at Battelle Memorial Institute preliminary to work of a more extensive nature.

An experiment discussed by Roberts-Austen[14] in 1899, and demonstrated a few years ago by Bardenheuer and Ploum,[124] was used to show the surprising quantity of hydrogen that may dissolve in steel during pickling. Two 3/16-in. rods, identical except that one had been pickled for ten minutes in dilute sulphuric acid, were rinsed and immersed in water heated to 95 deg. C. to accelerate effusion of absorbed hydrogen. The evolution shown in Fig. 4 is remarkable.

The extremely small size of discontinuity that is sufficient to permit the atomically dissolved gas to escape from the metal, and the tremendous pressure that prompts this escape, is demonstrated in the following experiments. Fig. 5 shows the bottom of an iron crucible that was coated with ordinary white paint. Dilute sulphuric acid inside the crucible provided atomic hydrogen that diffused through the iron and escaped at the metal-paint interface to form insoluble molecules there under pressure. Unable to diffuse through the paint as rapidly as it was being precipitated, the gas blistered the paint. Tin-plate and rolled sheet form blisters by this same mechanism except that greater pressures are required.

Fig. 6 shows the bottom of a vitreous-enamel-coated pan. Dilute sulphuric acid was placed inside the pan and the steel was exposed to the acid by scraping the enamel loose with a file. In a short period of time the hydrogen generated inside the pan diffused through the steel bottom and escaped at the tightly adhering metal-enamel surface. Unable to diffuse through the enamel quickly enough, the gas developed pressures sufficient to throw pieces of enamel several feet away from the pan. That these gas pressures were not due to acid that had seeped through interstices in the steel was definitely proved by the blue litmus paper shown in the figure. The paper, dampened with distilled water and moved over the whole bottom of the pan, showed no trace of acid.

Edwards[67] welded two steel plates together with a quantity of oxide between them and found that pickling caused them to swell and buckle. An experiment similar to this was performed during the course of this study, except that the plates contained no oxide addition between them. In fact, precautions were taken while welding the discs together around their peripheries to prevent undue oxidation of the interface. Residual air on the inner surface could only have afforded an oxide layer of submicroscopic thickness. The compounded disc was heated to 1100 deg. C., rolled to one-half its original thick-

Fig. 4B. Same as Fig. 4A, 5 min. later.

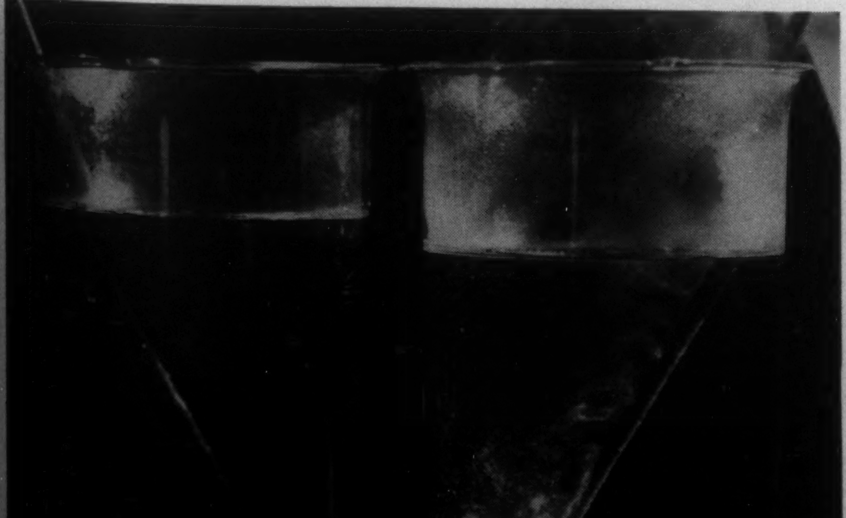


Fig. 4C. Same as Fig. 4A, 10 min. later.

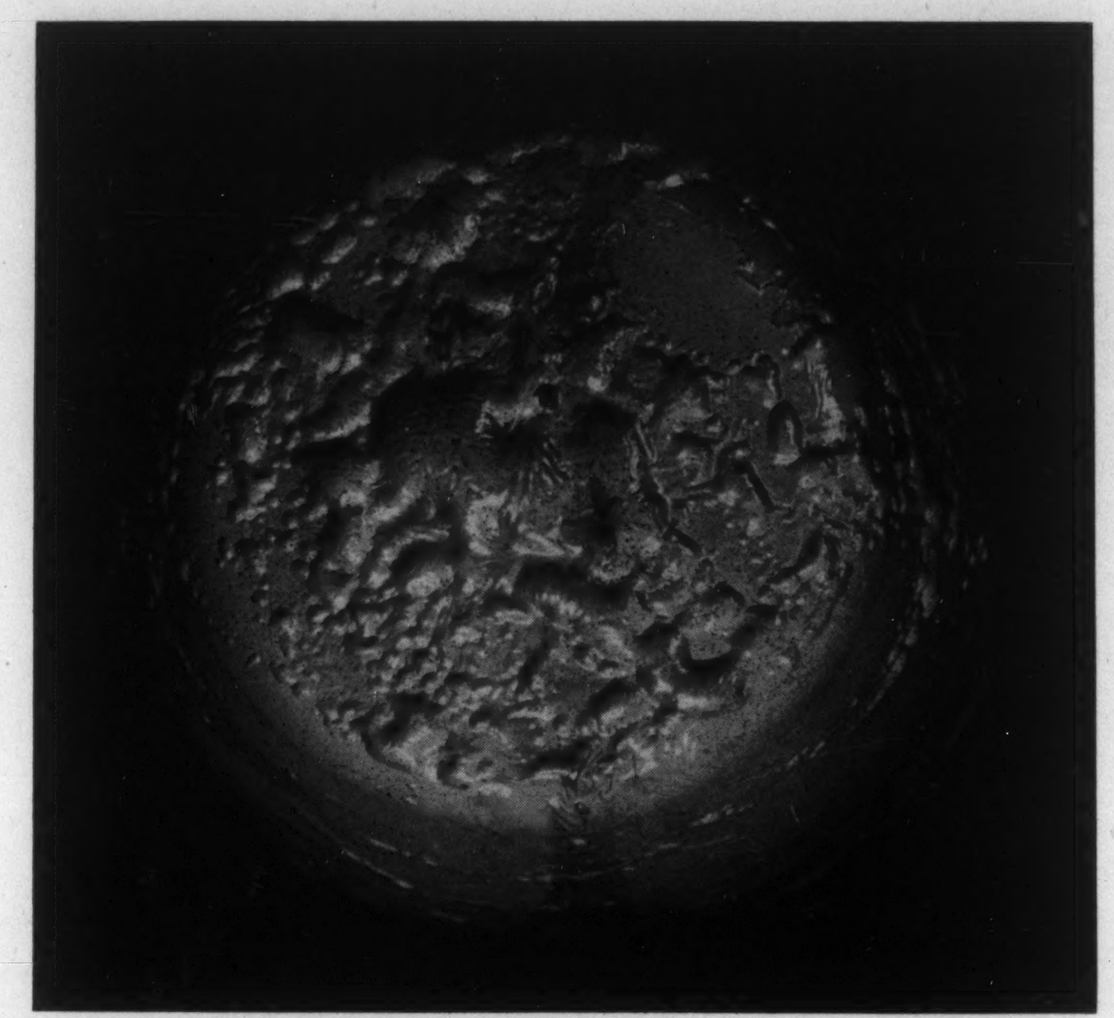


Fig. 5. Ordinary white paint blistered by hydrogen that has diffused through the bottom of an iron crucible. The crucible contained dilute sulphuric acid.

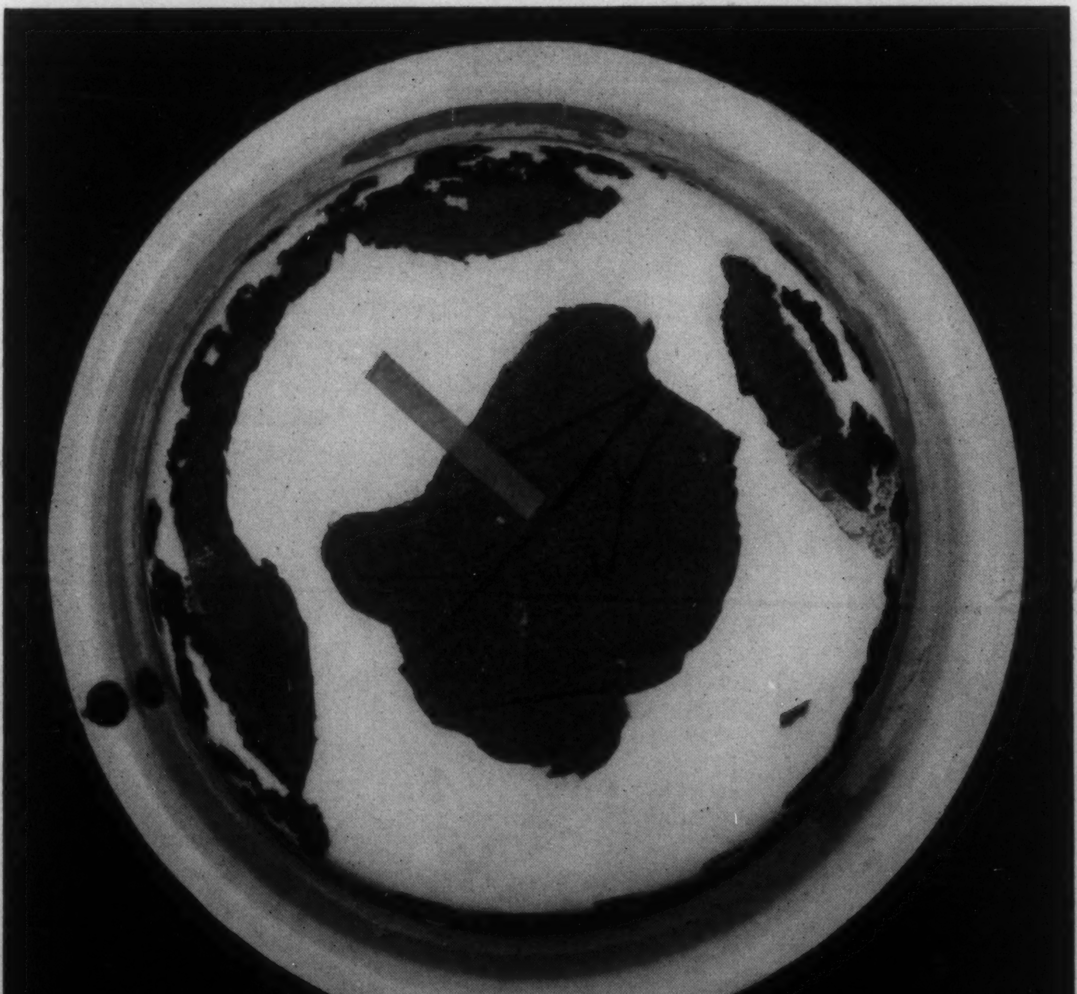


Fig. 6. Enamel chipped from the bottom of a pan by hydrogen gathering at the metal-enamel interface. Note litmus paper.

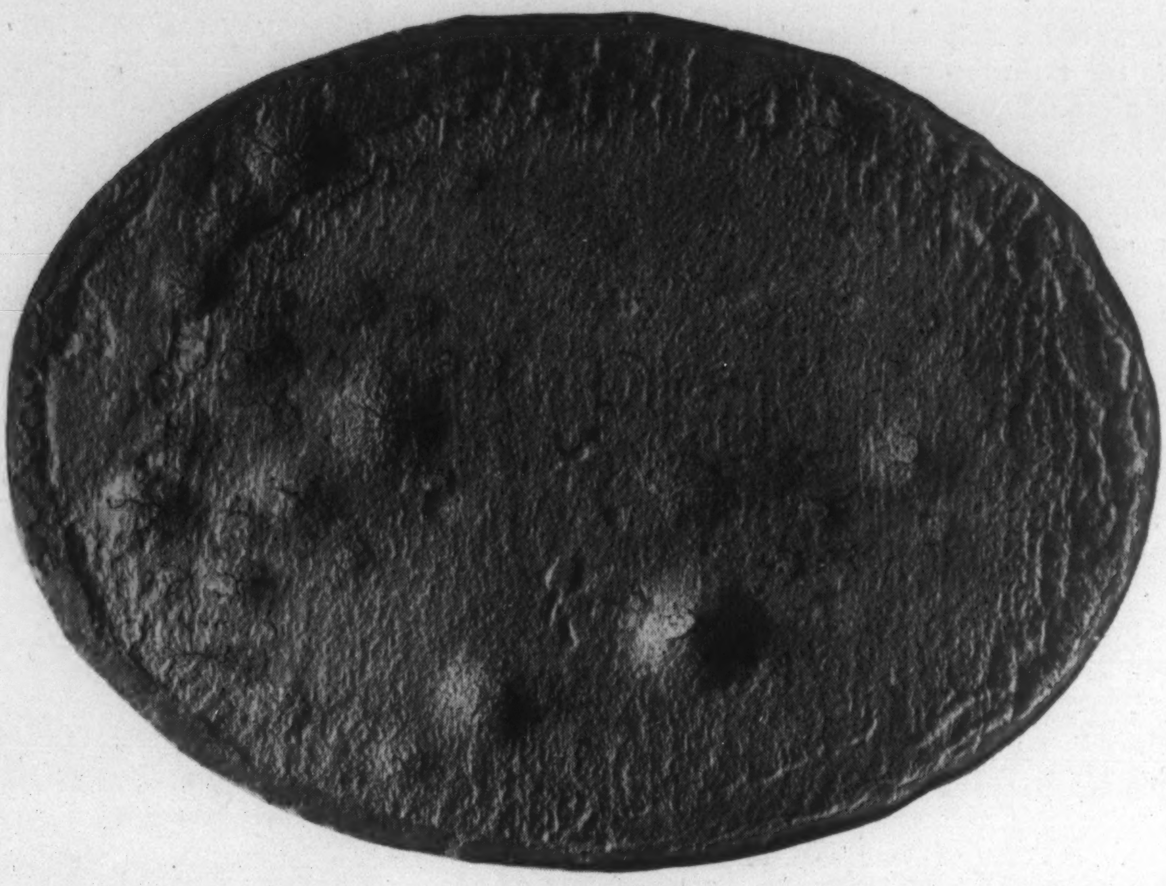


Fig. 7. Disc compounded from two 1/8-in. steel plates, rim-welded, rolled at 1100 deg. C. and pickled in sulphuric acid. The blisters are from trapped hydrogen.

ness and pickled. In several days the 1/8-in. steel swelled on each side to form blisters that must have required pressures of several thousand pounds per square inch for their formation. (See Fig. 7). The dispersion of the blisters and their small size indicates that most of the interface had welded together homogeneously during heating and rolling.

Bardenheuer and Thanheiser's experiment[92], wherein they succeeded in trapping molecular hydrogen under 300 atmospheres pressure, was also performed at Battelle Memorial Institute. Two tests were made, both employing loading the steel electrolytically with hydrogen. The apparatus (See Fig. 8) consisted of a cylinder 1/4-in. I.D. with 1/8-in. walls. The pressure increased approximately 100-lbs. per. sq. in. per day. In a second test a similar type of apparatus was used except that the cylinder was two inches in diameter with walls more than 1/4-in. thick. A gage reading higher pressures was used, but the gasket ruptured several times and the test was discontinued. Approximately one liter of atomic hydrogen had diffused through the 1/4-in. steel walls into a free-space of about 20 c.c. Bardenheuer and Thanheiser's[92] observation was verified, that the rate of pressure increase, and hence diffusion, is unhindered by the counter-pressure of the accumulating gas.

Four months after the test was discontinued the gage showed no decrease in the pressure, and it was necessary to drill the cylinder to permit the hydrogen to escape. Such occluded hydrogen cannot re-dissolve, it has been pointed out, until heated to about 800 deg. C. where dissociation and re-solution begin. This behavior is most significant, as it shows the mechanism whereby hydrogen, while apparently completely removed by low-temperature baking or aging, may still be retained in the steel. Subsequent processing of the steel that entails heating above 800 deg. C. will afford this trapped hydrogen a chance to enter the iron lattice once again. For example, during forging, the hydrogen trapped in porous or dirty steel will re-dissolve and later may cause flaking or other defects. In the same manner, even a forging that has been carefully annealed at a low temperature to eliminate flakes may still retain enough hydrogen in its inclusions to cause an unexpected return of flaking after subsequent forging. This latter case is exceptional, however, and when it does occur the number of flakes that appears is greatly diminished.

In the case of reboil blisters on enamel-coated steel the quantity of hydrogen necessary for the phenomenon must be considerably less than that required for the production of flakes in steel. The enamel industry should perhaps consider hydrogen in steel more seriously, as the observations on reboil blistering that they report are quite readily explained as functions of hydrogen. That the enameling procedure provides a great supply of hydrogen in the steel to be coated is demonstrated in the experiment shown in Fig. 9. Here the standard procedure of preparation for annealing has been followed in the three beakers on the left as follows:

Sulphuric acid	77 deg. C.	(170 deg. F.)	10 min.
Water rinse	77 deg. C.	(170 deg. F.)	1 min.
Neutralizer	83 deg. C.	(180 deg. F.)	3 min.

A 3/16-in. steel rod was used as a specimen similar to the experiment shown in Fig. 4. After the neutralizer, the specimen was rinsed and, at the time when the specimen in the actual process is coated with enamel and fired, the rod was immersed instead in water heated to 95 deg. C. The heavy evolution of hydrogen, which lasted for nearly ten minutes, is significant in the face of the trouble that the enamel industry reports regarding blisters on enameled steel.

(To be continued)

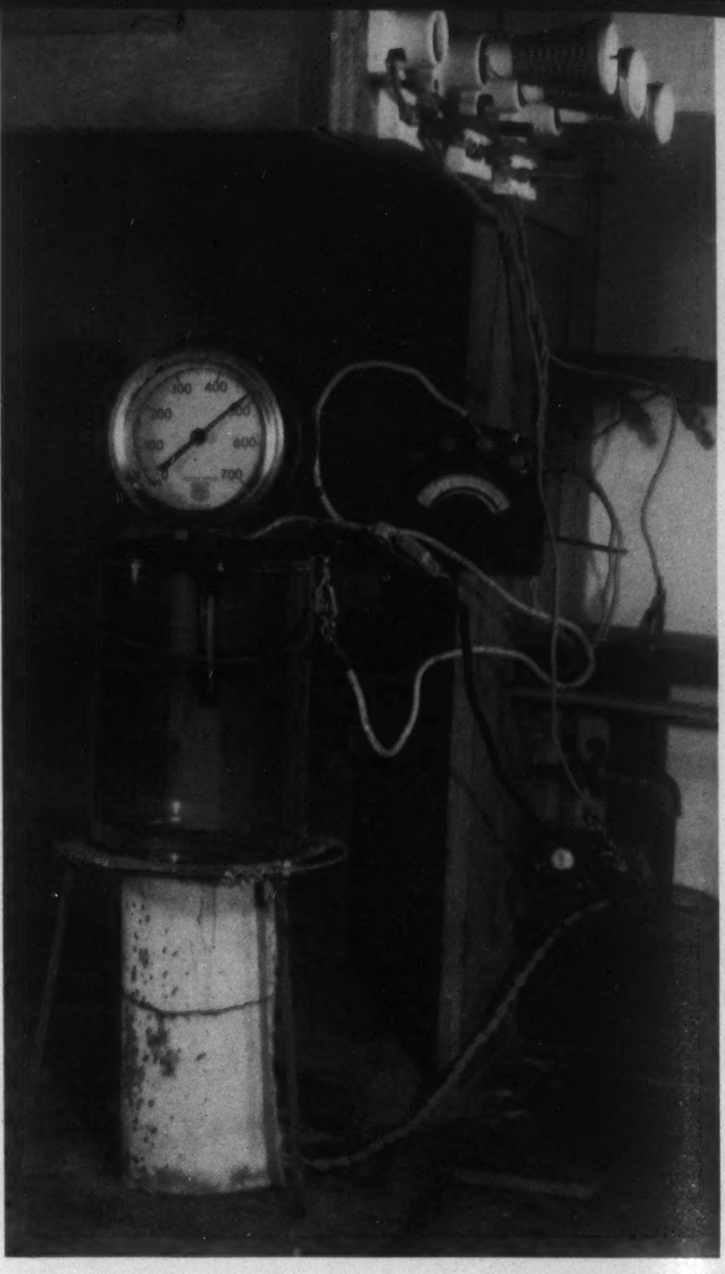


Fig. 8. Apparatus for measuring the pressure developed by trapped hydrogen.

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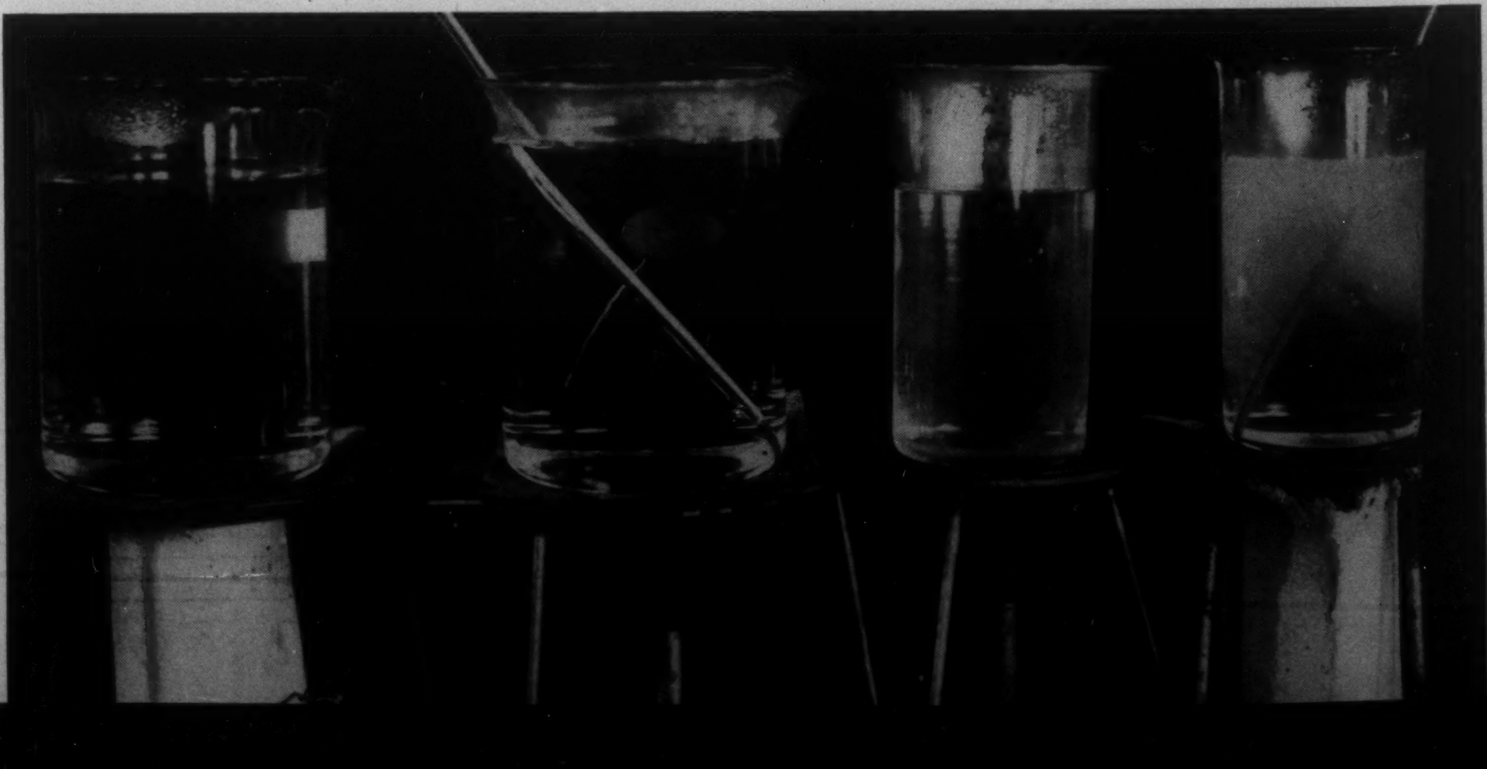

Fig. 9. The 3/16-in. rod in the beaker on the right is evolving hydrogen absorbed during standard preparation for vitreous enameling. The beaker on the extreme left contains sulphuric acid with a water rinse in the second one and a sodium carbonate neutralizer in the third. The one at the extreme right contains hot water.

Induction Melting and Soldering in the Optical Industry

by W. J. WRIGHTON and T. C. JARRETT
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UNTIL RECENTLY, LITTLE HAS BEEN SAID about manufacturing methods in the optical and closely related jewelry industries. Some phases have been discussed in previous articles.[1-2-3] This article describes some of the later developments of induction heating as practiced in the Southbridge plant of American Optical Co.

Melting and soldering by means of induction current has entered the picture, and now plays an important role in the manufacture of optical materials, such as gold alloys, gold-filled wire and flat plate.

High Frequency Melting Necessary

The high frequency induction melting furnace now being used in the optical industry makes possible the melting of complex gold alloys. (Fig. 1.) The alloys could be melted in the old conventional oil or gas furnace, but lack of homogeneity would appear in the old type of melting. This is particularly true when a high percentage of nickel is involved. The induction method increases production as well as the quality and uniformity of the product.

The average weight of the gold alloy melted in a 35 k.v.a. induction furnace is about 120 ounces and, when cast, produces an ingot 3 by ¾ by 11 in. long.

When pouring a gold alloy of a high nickel content, a temperature of 2000 to 2400 deg. F. is necessary. In many cases oxides form while pouring, a condition overcome to a great extent by pouring under a dry hydrogen atmosphere. This method is illustrated in Fig. 2. Before pouring, the burning gas is forced into the hot mold to remove the last traces of air, and then turned down to a lazy flame over the mouth of the mold. As the molten gold alloy is poured into the mold, the hydrogen also finds its way into the crucible, thus protecting all the molten metal from the air.

Low Frequency in Soldering

It is an established fact that the lower the frequency, the greater the depth of penetration of heat. This increased depth of penetration is necessary in the next step in the manufacture of gold-filled wire and plate.

Increased heat penetration is even more essential in the use of oblong plates. Plates to be soldered are 3½ in. wide and 7 in. long and it is necessary to heat the entire plate uniformly. By using low frequency currents, this requirement is fulfilled. The equipment required to do this is shown in Figs. 3 and 4. Low frequency current is applied to the gold-filled assembly while it is under pressure. The laminations of the furnace act as the press while the coil surrounding the assembly and laminations supplies the heat and energy. The coil itself is water cooled and employs 60-cycle current. Voltage on the secondary may be varied from 120 to 160 volts, while the amperage may vary from 300 to 1200. The greater the amperage and voltage, the greater the amount of heat and speed of heating.

Assembled gold-filled plates to be soldered (solder and flux are sandwiches between the plates in the assembly) are placed between two heat distributors, and in turn between the laminations which make up the press and furnace. The heat distributors are copper plates which aid in the distribution of electrical energy. Pressure is applied and, as the laminations close, the furnace drops into place. Automatic time devices cut off the current when the approximate temperature is reached, but it is necessary to watch the flow of the solder. The soldered gold-filled plates are allowed to remain under the 2000 to 3000 lbs. pressure until the solder has solidified.

This method of soldering composite gold-filled wire or flat plate reduces the scrap loss considerably, and permits more accurate control of soldering and improves the finished product.

High Frequency Also in Soldering

The third step in making gold-filled wire is the soldering of the shell to the core.[2] In this case, high frequency current is employed. A 6-9 k.v.a. standard high frequency unit is employed, using a furnace and mechanical apparatus of special design. (Figs. 5 and 6.) The coil is 15 in. long and 2 in. in diameter. A quartz tube is employed inside the coil to protect it from short circuiting across the work being soldered. The assembled gold-filled bar is placed between two stainless steel points and the furnace in turn placed over it. During the soldering operation the bar is revolved to prevent excess local heating. About 7 k.v.a. is used to solder a bar, and about 9 min. is required to complete the operation. This method affords better control, greater speed, and ease of operation.

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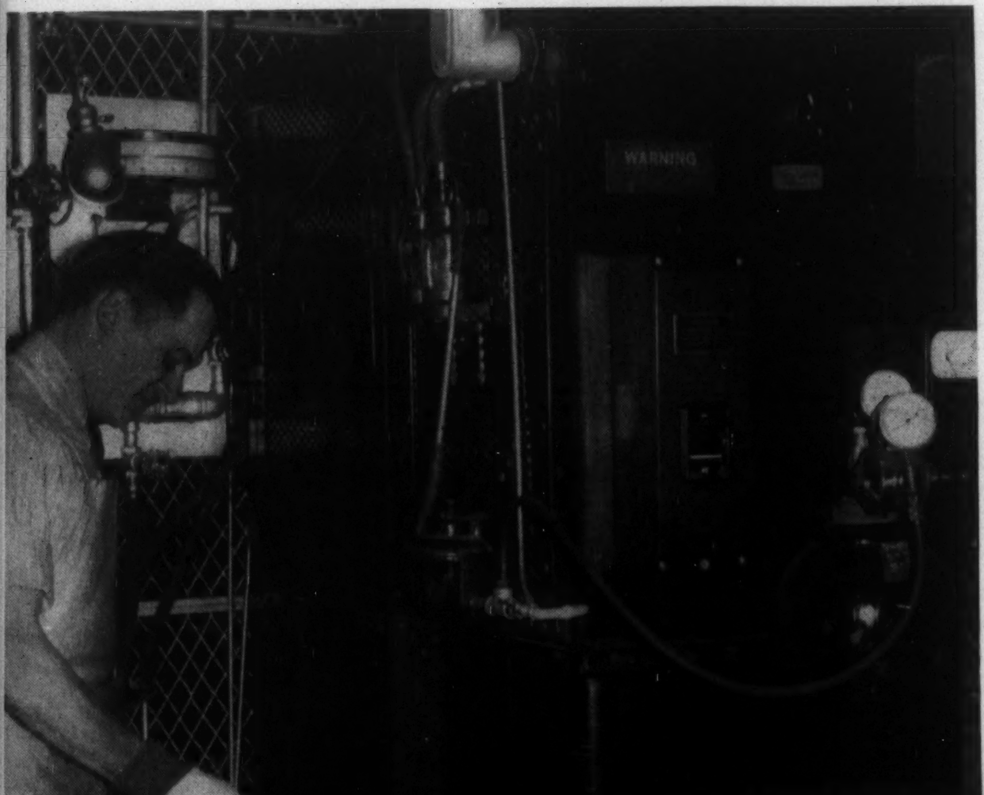


Fig. 1. Melting gold alloys by means of high frequency induction currents.

Fig. 2. Pouring molten gold alloy under a dry hydrogen atmosphere.

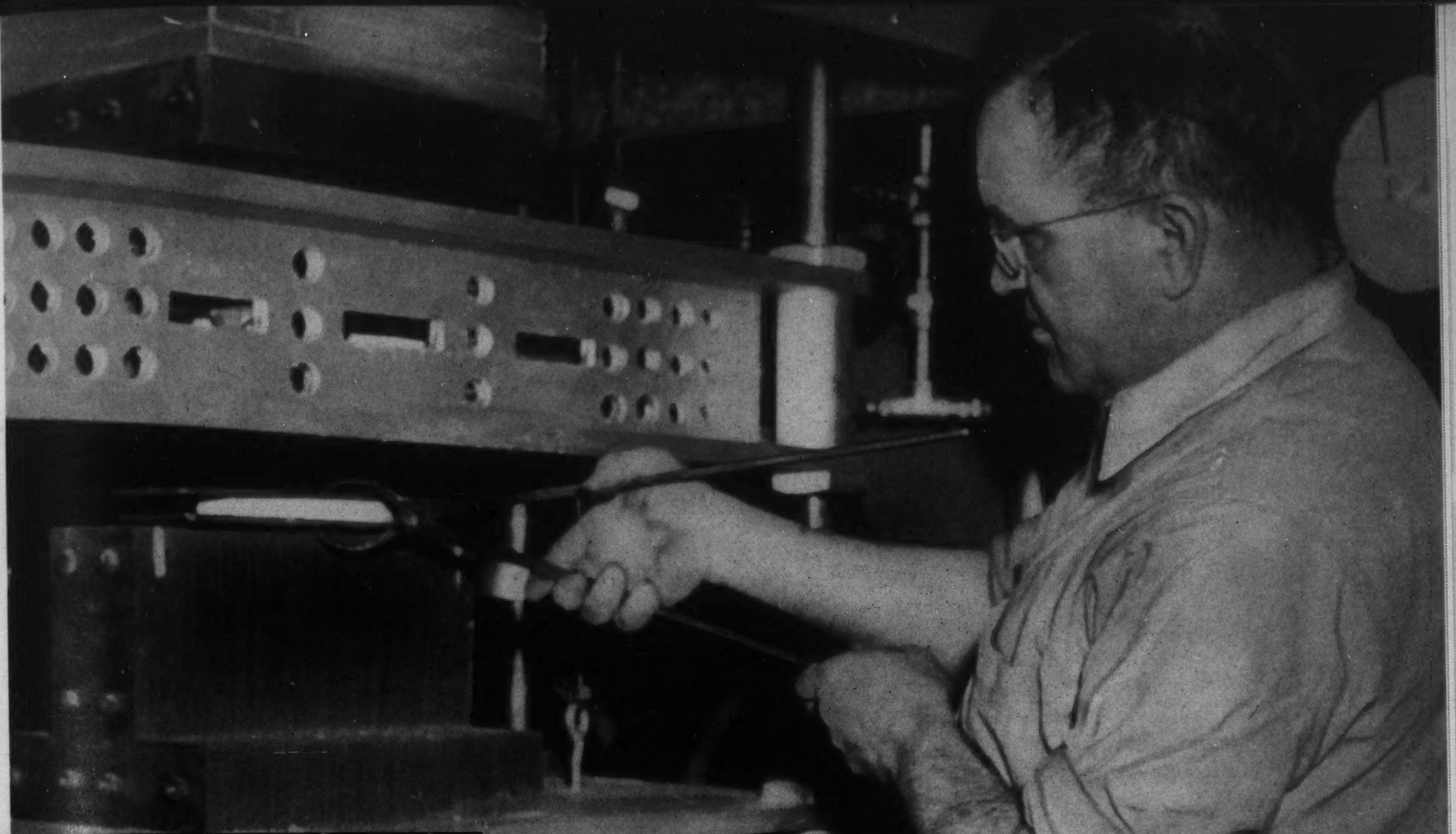


Fig. 4. (Above) Gold-filled assembly and heat distributor plate being placed between furnace laminations.

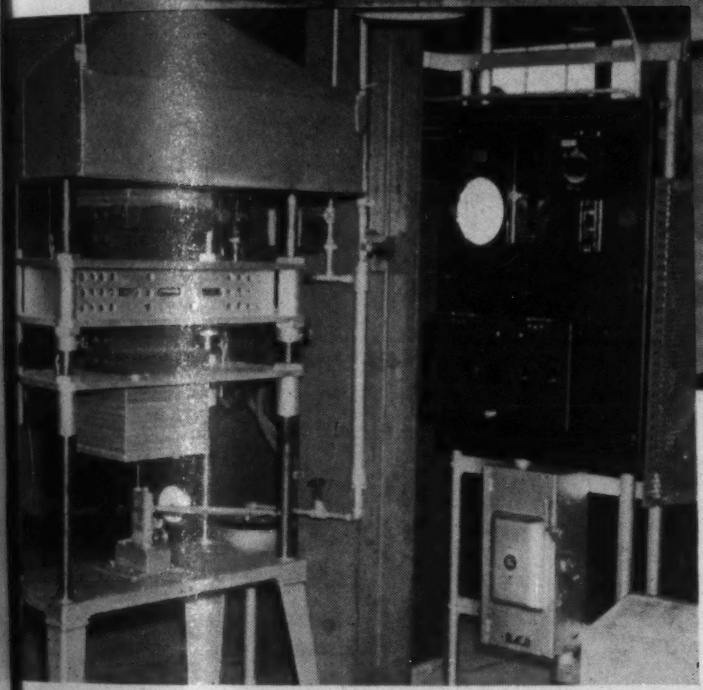


Fig. 3. Low frequency induction soldering furnace showing mechanism and controls.

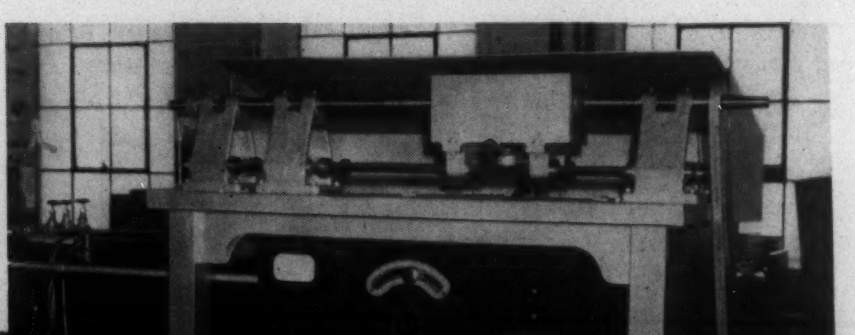


Fig. 5. High frequency induction bar soldering furnace showing controls and mechanism.

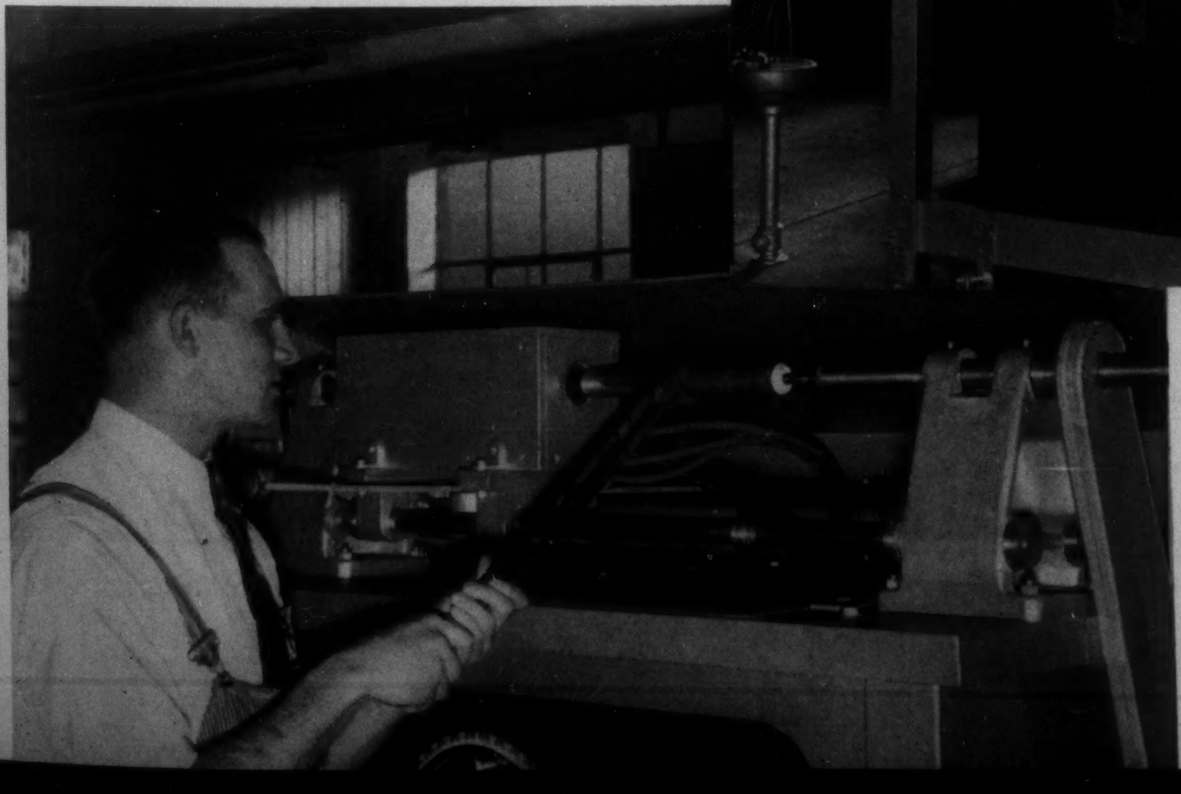


Fig. 6. Assembled gold-filled wire bar being placed in position for soldering.

Editorial

(*Continued from Page A37*)

in the heat-treated wire.

Kommers has called attention to the work of Memmler and Laute on properties conferred by understressing in fatigue. In this work the change in behavior in the low stress end of the tensile stress-strain diagram gave valuable indication that the type of action which was occurring was analogous to that of a skin pass in cold working.

Not only in creep at elevated temperature, but also in various types of service at room temperature, we ought to be asking, "What occurs at the very onset of plastic flow?"

In deep drawing steels, it seems likely that the lower the stress at which this begins, the better. In springs, it may need to be very high. In materials for use under repeated stress, where "crackless plasticity" is needed, perhaps it should be very low. At any rate, we would like to be able to tabulate this figure along with the others we use in sizing up the results of alloying or heat treatments. As attention becomes focused on this stage of deformation, it becomes increasingly necessary to have a reliable basis for comparing different alloys in regard to their earliest plastic behavior.

The old uncertainty as to precision of measurement at the "proportional limit" no longer holds. Modern shops can measure to a high degree of precision. Showing that a 2.00000-in. gage length has stretched even as little as to 2.00004 in. is no job nowadays and showing that it has stretched to 2.000004 in. is not particularly difficult with modern extensometers.

It would be best to have complete stress-strain and stress-set curves by which to compare different materials, but you can't tabulate curves. Even one more point on the stress-set curve would help a lot, say that corresponding to 1/10 the plastic deformation at the (0.2 per cent) yield strength, i.e., 0.02 per cent set, or 0.0004 in. in 2 in. Now and then such a figure is cited. German work often reports both σ 0.2 per cent and σ 0.02 per cent "grenze" (= limit of "bleibende Dehnung" = permanent set). It would fill an aching void if, as well as the 0.2 per cent value, the 0.02 per cent offset value (and perhaps also the 0.02 per cent set value) were on record for all materials and treatments.

The subscript terminology is precise, but clumsy. Human nature is such, in this country at least, that we will not long endure a clumsy expression like "0.02 per cent offset yield strength"; we'll nickname it, sure as fate. Few people bother to state, in reporting yield strength, that it is the unit stress for 0.2 per cent offset, for they feel that this is implied.

Since that amount is called for in Navy specifications, one pet name for the value is "Navy yield strength." Some pet name is needed for a value denoting a definite, and much smaller, amount of set.

There would be a real advantage in a brand new name which had never meant anything else and which had never failed to have one definite and specific meaning. Perhaps two names are needed, one for the 0.02 per cent offset value and one for the 0.02 per cent set value, since the values are not necessarily the same, for changes in treatment of some ordinary structural materials which increase the offset at a given stress decrease the set at the same stress and vice versa. What should we call these values? Neither "elastic limit" nor "proportional limit" is a rigorous term, and both have been too loosely used to be amenable to a new, precise, definition.

In searching for a term to describe the 0.02 per cent offset yield strength (1/10 the plastic effect of the regular yield strength and similarly determined), all we need is some adjective! The value is already recognized as a variety of yield strength, for A.S.T.M. E6-36 and E8-36 say "the elastic limit and the proportional limit are special values of the yield strength. They are the highest stresses for which the 'set' and the 'offset' respectively are not measurable with the instruments used and hence are considered to be zero." That is, when we quit kidding ourselves about the zero business, the value we have in mind is a yield strength in the diaper stage. Actually we are thinking of a - more - precisely - determined - yield - strength - at - a - smaller - set - than - the - usual - yield-strength, but it is still a yield strength.

"Minor," "initial," or "primitive" yield strength, "slip limit"; any of these might serve if people could agree upon it. Perhaps we could call the 0.02 per cent offset value the "Army yield strength," connoting that the Army gets some 10 per cent as much appropriation as the Navy, since "Navy yield strength" seems quite acceptable. One commentator says that our personal term, "diaper yield strength" is expressive enough but "would shock the A.S.T.M. and possibly even the A.S.M."

This all reminds us of a conversation we had with a French Canadian youngster last summer, consisting of our pointing to an object and the youngster telling us its French name. We pointed to a tiger lily. The youngster said "onion." This seemed peculiar, so we pointed to a real onion in the same garden. We then got the information that the lily was an "onion to look at," the other an "onion to eat." Since both had bulbs, this was logical, once it was explained.

Most of the experts so far consulted say we do need some simple words which are not misleading but they can't think them up. Who can?

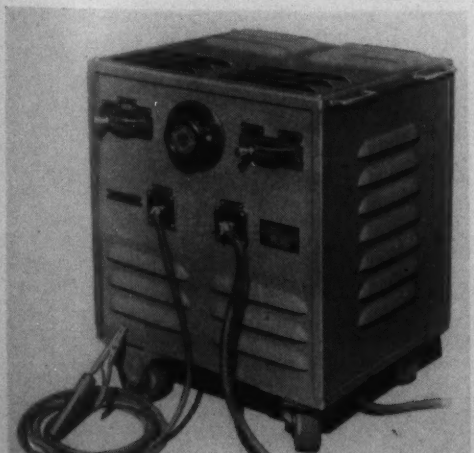
Probably the important thing is to get the data, rather than to hunt for the words, but the data won't come till some authoritative body says that, for purposes of intercomparison, people should determine a small set, of a given magnitude, in a given way. We think it might be easier to stir up interest in establishing a committee to set standards for determination of the "primitive yield strength" or whatever we want to call it, than for the "0.02 per cent offset yield strength."—H. W. G.

New Equipment and Materials

Electronic Arc Welder

Allis-Chalmers Mfg. Co., Milwaukee, has come out with a novel design of low-current electronic arc welder for precision work. This so-called "Weld-O-Tron" unit can be used to weld with currents as low as 5 amps., using newly developed 1/32 and 3/64-in. electrodes. Steels, stainless steels, and other metals lighter than approximately 18 gage, which hitherto could not be welded satisfactorily without seriously burning the metal and destroying many of its vital properties, can now readily be welded, it is claimed. As a result, this new equipment is said to be applicable to many types of work previously considered too small or too light in construction for anything except riveting, spot welding, brazing or even soldering. It is stated that sheets as thin as 0.010-in., or approximately 32 gage, can be handled without any difficulty.

The heart of the Allis-Chalmers portable Weld-O-Tron electronic arc welder is a multiple tube polyphase mercury vapor rectifier unit. It makes use of the newest type of rectifier tubes, specially developed for this equipment. The unit combines light weight, long life, and absence of rotating parts with the advantages of both a-c and d-c arc welding. The readily accessible controls and terminals are of the dead front type, and are located on the control panel. Two of them are simple 2-way switches, one for current range selection, the other for reversing polarity of the tube terminals. A hand wheel, with easily readable dial, provides fine adjustment of the welding current. According to the company, a constant current characteristic has been given to the Weld-O-Tron which makes the arc easy to start, easy to hold and which produces the optimum heat conditions at the weld. The same characteristics are obtained from minimum to maximum current settings. The new unit now being offered, and more completely described in Bulletin B-6049, was evolved to handle some of the company's own intricate work for which, it is said, there was no suitable machine on the market.



Manufacturers are invited to send to the Editor items which are suitable for this Department. Illustrations are acceptable, preferably in the form of cuts not more than 2 in. wide.

Speedy Method of Castings Finishing

New Wrinkle, Inc., Dayton, Ohio, licensors of "Wrinkle Finishes" under the patents held by the company, has recently developed what is known as the New Wrinkle Dip-Process of Castings Finishing, which is expected to result in desirable indirect advantages to foundries and doubled production for castings users—decided savings to both.

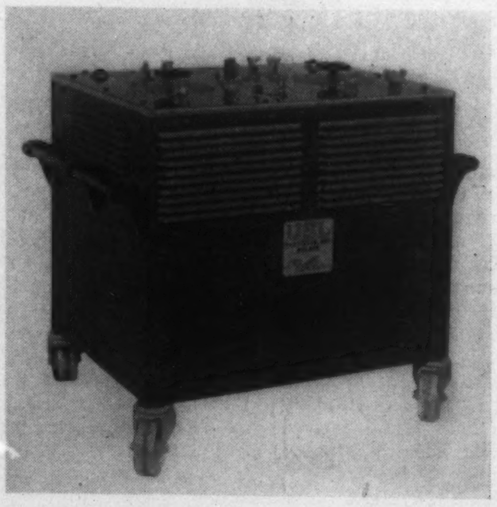
In recent years foundries have been called upon to meet rigid specifications calling for ultra-finished castings. The New Wrinkle Dip-Process of Castings Finishing takes this situation into consideration, directing its full desirability first to the foundry as an indirect aid in eliminating costly mechanical castings finishing operations; second, to the castings user who in applying it saves money in his initial purchases as well as materially reducing his inside finishing costs. The process coordinates the merits of Wrinkle Finishes with three simple steps: (1) The casting is dipped in a thin solution of Wrinkle Finish. This dipping process not only insures complete coverage for all exposed-to-the-eye surfaces, but securely seals all the pores on hidden surfaces where rust-proofing is the only duty a finish serves. (2) The casting is placed on a slightly inclined, removable screen-covered rack so the surplus paint is collected in a tray which returns it to the dipping tank. By racking the castings in this manner and letting them stand for several minutes, the finish is given an opportunity to set. (3) The casting is now ready for a quick spraying accomplished with a minimum of waste as the atomized material readily adheres to the wet casting surface.

During the baking operation which follows, New Wrinkle effects the change which has made it one of the most popular finishes today. It provides both an attractive appearance and a hard surface that cannot be marred very easily. The results achieved through the New Wrinkle Dip-Process of Castings Finishing are claimed to be as follows: (1) Lower initial cost of castings at the foundry; (2) output of castings in the finishing department doubled; (3) saves 25 to 40% on finishing materials; (4) assures complete surface coverage to seal casting pores against rust; (5) eliminates rejects which average 20% under ordinary finishing conditions; (6) does not require costly equipment. The additional equipment needed in a dipping tank and rack which can readily be made in the product finishers' own plant.

The "3W" Welder

The Owen-Dyneto Division of the USL Battery Corp., Syracuse, N. Y., has announced a new 500-amps. AC welder, termed its "3W" which completes its new line ranging from 150 to 500 amps. It is designed to operate on either 220 or 440 v. and can be operated by 2 operators simultaneously from 30 to 280 amps. each by simply shifting a copper bar on the top of the welder and can be operated from 30 to 560 amps. having a continuous 500-amp. rating.

The company states that the electrodes, 1/10 to 1/2 in. in dia. inclusive, can be used with this machine which makes it possible to weld the thinnest automobile body to the heaviest truck frame. The machine weighs 460 lbs.



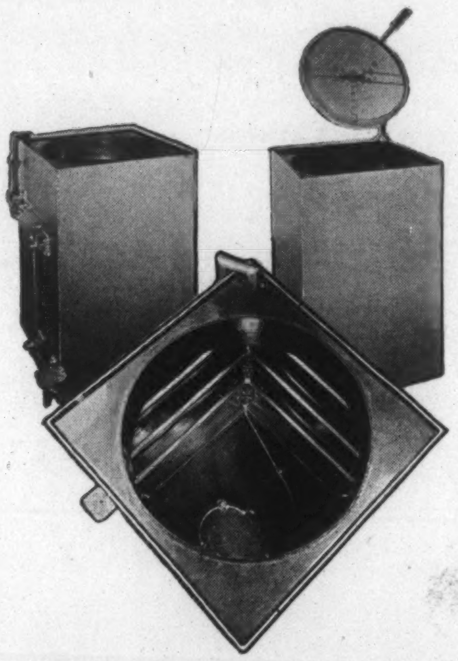
Anode Bags

A new anode bag, "Style D," is the latest development of the Hanson-Van Winkle-Munning Co., Matawan, N. J., manufacturers of electroplating equipment and supplies. "Style D" bags are made from a closely woven Sanforized drill material. They are 5 in. wide, single ply with a special sewing. For anodes 12 to 20 in. long the bags are 4 in. longer than the anode. Anodes 20 to 40 in. long require bags 5 in. longer than the anode as there is more room needed for the collection of sludge. In place of draw strings these bags are fastened to the anodes by two pieces of tape which pass through holes punched through the bag ½ in. down from the top. The bags are impregnated top and bottom with a red resin.

The advantages of these bags can be summed up as follows: 1. The impregnated resin tip greatly prolongs the life of the bag. 2. The resin coated bottom of the bag forms a pocket for the sludge, largely carbon, which accumulates as the anode corrodes. 3. With the top of the bag stiffened by the resin, a much simpler method of fastening the bags to the anodes is possible. 4. The proper solution level can be determined at a glance.

High Velocity Spray Rinse for Plated Work

Newly introduced by Storts Welding Co., 102 Stone St., Meriden, Conn., is the "Vortexeddy" spray tank especially designed for racked parts rinsing in electroplating departments. The rinsing operation is performed by alternate vortexes of spray streams circulating clockwise and anti-clockwise, and interrupted by other straight line spray streams which produce a multiplicity of eddies moving in as many directions. Provision is made for turning the work so that every portion of the surface is subjected to the impact of the high velocity atomized rinse water from numerous angles. In the operation of this new type of rinse tank, water flows only while the work is in rinsing position and a spray of great fineness and density at high speed replaces the greater mass of quiet water in the conventional still rinse tank.



Two advantages claimed for this change in process are savings in water consumption from 38 to 86%, and a time saving up to 65%. The more energetic rinsing action is said to accomplish a cleaner rinsing, which allows the use of more effective cleaning agents that are not now widely used because they are so difficult to rinse. Then, due to the fact that only fresh uncontaminated water makes contact with the work, contamination of acid and alkali solutions is eliminated and one spray tank can be made to replace from 2 to 4 still rinse tanks by a cross aisle arrangement of the plating cycle.

Both foot-pedal and hand-lever types are available, the foot-pedal type being convertible for either left foot or right foot operation and the hand-lever type convertible for either left hand or right hand control. Standard sizes are: 24 by 24 by 36 in. deep with 21-in. dia. top opening, 30 by 30 by 36 in. deep with 27-in. dia. top opening and 36 by 24 by 36 in. deep with 33 by 21-in. oval top opening. Both types can also be furnished to any square or rectangular dimensions with round or oval top openings to suit rack and work dimensions and other requirements.

The tank itself is of Armco ingot iron plate, double welded with "post of metal" welds, which stiffen the corners structurally and leave no re-entrant crevices subject to corrosive attack. The inside area and all surfaces of the top opening cover are double coated with resinous corrosion resisting material and the outside is finished with two coats of aluminum asphalt paint. Spray coils are made of full wall thickness standard brass pipe. The full jet spray nozzles and all other fittings are brass or bronze. Clean-out openings on header and ring pipes are accessibly located for grit removal from inside of pipe without removing coil from tank.

A Vertical Turret Lathe

The Bullard Co., Bridgeport, Conn., announces one of its latest achievements—the "Cut Master Vertical Turret Lathe."

This machine is based on the fundamental principles of design and incorporating the results of acquired knowledge through research over the past 60 yrs., as well as studied engineering of the present demands for machine tools. This new line of machines, therefore, ranging in 5 sizes—30, 36, 42, 54, and 64 in.—offers manufacturers a line of machines engineered to the last detail for economical, efficient, and accurate manufacturing, says the company. These machines are designed to conform to the utmost capabilities of our modern carbide and other cutting tools, with wide range of feeds and speeds, plus the ability to stand up under high horse-power loads. Furthermore, their basic design widens the useful scope of these machines as compared to previous machines of this type. As a matter of fact, on test one set of single tungsten-carbide tools removed 220 cu. in. of cast iron per min.

With the exception of the 30 and 36-in. machines which alone are designed for 2 heads, a main turret head and a side head, these machines are designed to carry 3 heads: Left hand main ram head, a right hand main turret head, and the side head. However, any choice of heads are available to meet the requirements of individual cases. All heads and functions of the machines are protected by interlocking and limit switches, so that it is claimed almost an impossibility to damage the machine through forgetfulness or careless handling. Either rail head may be swiveled 30 deg. either side of vertical center for machining angular surfaces, and the heads can also be fed horizontally and their respective rams fed vertically at the same time for machining any angles up to 45 deg. Furthermore, if the main heads are set at angles varying up to 30 deg. off vertical center and the heads and rams given their respective feeds, angles ranging up to 60 deg. may be produced. The two main heads are provided with screw feed, both horizontal and vertical, which assures extreme accuracy, smoothness of movement, and fine finish of the work in process, it is said.

Combining traverse and feed control into one lever, in the center of each handwheel, one for the turret slide and another lever for the saddle movements, has greatly simplified these operating functions, it is pointed out. With this design there is a natural interlock which prevents feed and traverse from being engaged at the same time. However, feed of the slides does not prevent rapid traverse of the saddle or vice versa. The power traverse control is sensitive in action and provides rapid, individual, and simultaneous action for vertical or horizontal movement of both main saddles and rams as well as the side head and its ram. The feed and traverse levers are located in the center of each handwheel where, by a simple movement, the feed is stopped and the head and tool brought up to the finish cut by means of the hammer hand wheel. Each head has its own feed works which functions irrespective of the others, and feed changes are easily and quickly made without stopping the machine or removing the heads from the work.

Electric stops are provided for feeds of all heads in any direction, and provide feed stop-off when approaching finished dimensions. The moving members are equipped with fixed switches which contact the adjustable trip dogs at any point of desired setting. This action closes the circuit, thereby reacting on thrustors which in turn disengage the feed. On the turret head there is a selector bar which permits of separate trip dogs for each station of the turret. As the turret is indexed, the selector bar moves to each respective position. Trip dogs are easily adjusted, and when once set for their respective dimensions, they assist greatly in the duplication of these dimensions. There are 16 changes of feeds and 20 changes of speeds, all in geometric ratio. Furthermore, a 25% higher spindle speed range can be provided if desired. Clamping of the rail and other sliding members is provided for by binder bolts and levers, but because of the rigid construction, it has not been found necessary to make use of these.

It is possible to safely operate these machines at the higher speeds because of the 100 per cent large Timken bearing spindle mountings. Furthermore, positive pressure filtered lubrication throughout the machine and the anti-friction bearings at other points assure it is said, long life with minimum maintenance cost, even under the heavy cutting or the higher speeds to which these machines can be subjected. New design chucks minimize friction within the mechanism, thereby providing maximum jaw pressure with minimum expended wrench effort. These chucks are available in 3-jaw universal or 4-jaw independent type having conventional T slots for securing jaws, fixtures, clamps, and other devices.

Because of the postponement of the Machine Tool Show in October, there are now three of these machines—the 30, 42, and 64-in.—running in the Bullard plant and available for inspection.

Precision Die Sets

The Danly Machine Specialties, Inc., of 2130 South 52nd Ave., Chicago, announces a new and enlarged line of "Danly Precision Die Sets" in a wide range of sizes of regular, reverse and long narrow die sets for any die from 3 by 3 in. to 25 by 14 in., in many thickness combinations of die holder and punch-holder. Included also are a new "square" series of back post sets for mounting square and round dies, also in a complete range of sizes from 3 by 3 in. to 14 by 14 in.

Danly Precision Die Sets are assembled with precision guide post and bushings. Danly Precision Guide Posts are hardened, ground and lapped to tolerances of plus or minus one-ten-thousandth of an inch. Precision bushings, of standard, shoulder and extra long types are ground and honed to the same accurate limits. These sets are interchangeable. Any die holder or punch holder of the same center distances will fit with any other die holder or punch holder of the same dimensions, it is announced. This makes available a wide variety of thickness combinations, as each Danly set is assembled to order to the customer's specifications.

Assembly plants and complete stocks are maintained at each of the company's 8 branches. All new types and sizes will also be available in the commercial line. A feature of the catalog in which the new sets are announced is a graphic chart showing the complete range of sizes of standard Back Post Sets, making selection of the right size, a simple sure procedure.

A Black Electroplated Finish

The new du Pont "Moly-Black" (molybdenum-nickel) plating process (patent applied for) represents an outstanding improvement in the production of black coatings by electrodeposition. Deep-black lustrous deposits which are suitable as protective and decorative finishes can be obtained without difficulty by the average plater. The plating is rapid—0.001 in. in 10 min. plating time.

The process operates in the usual nickel-plating equipment and is easily installed, maintained and controlled to produce consistently good results. The Moly-Black plating solution is readily made up and maintained from prepared salts. Unlike other solutions used for black plating, it is not sensitive to slight changes in operating conditions.

Moly-Black plating is described by the electroplating division of the E. I. du Pont de Nemours & Co., Wilmington, Del., as offering attractive possibilities for the economical production of decorative and protective black finishes on a wide variety of products such as: Ash trays, book ends, statuary, and trophies; mechanical parts for cash registers, typewriters, tabulators, etc., counter dials, carriage frames and metal furniture; microscopes, cameras, telescopes, etc.

The Moly-Black finish can be applied to a variety of base metals or plated metals, viz.—zinc-base die castings, most forms of aluminum, electroplated zinc, electroplated cadmium, electroplated or hot-dipped tin, gray nickel plate, and iron or steel. Black deposits over iron or steel should be oiled or lacquered.

The attractive coating which can be obtained over all of these base metals makes this an unusually decorative finish for articles to be used indoors. For outdoor articles, the black plate should be deposited over an undercoating of cadmium and then lacquered.

(Continued on page MA 4)

"A.W." *Quality* PRODUCTS *from Mine to Consumer*

"SWEDE" PIG IRON
Foundry, Malleable and Basic Grades.

INGOTS
Standard and special sizes furnished in any Open Hearth analysis.

BLOOMS, BILLETS & SLABS
Alloy, Forging and Rerolling qualities.

SHEARED STEEL PLATES
Special Alloy, Tank, Ship, Boiler, Flange, Firebox, Locomotive Firebox, Structural and Dredge Pipe qualities.

HOT ROLLED SHEETS
All qualities, special Alloy, Annealed, Blued Finish, Hard Red, Pickled, or deoxidized to meet your needs.

FLOOR PLATES
For every kind of flooring condition: "A.W." Super Diamond, Standard Diamond, Diamondette, Sunken Diamond and Ribbed Patterns. Any pattern furnished in ferrous or non-ferrous analysis.

CUT STEEL NAILS
"Reading" Brand—all types and sizes or any special types produced.

FOR Carbon, Copper or Alloy Steels—in *any* Open Hearth analysis, in *any* quantity—ALAN WOOD can meet your specifications.

Do you want to reduce dead weight in mobile equipment, as well as stationary structures? "A.W." DYN-EL has been designed for this purpose. It has corrosion resistance better than ordinary Steel, excellent welding qualities with good forming qualities.

Do you need welding qualities, toughness, abrasion resistance, exceptional ductility or any other special qualities? There is an "A.W." Steel made to ALAN WOOD standards that will give you best results at the lowest possible cost.

The Metallurgical Department is the customer's representative in the ALAN WOOD plant—prescribing the purchaser's requirements in terms of Steel plant practice; inspecting and testing the finished product to insure compliance with purchaser's specifications.

"A.W." service includes cooperation of its entire organization to insure prompt execution of special mill orders.

ALAN WOOD STEEL COMPANY

MAIN OFFICE AND MILLS, CONSHOHOCKEN, PENNA. : : SINCE 1826 : : DISTRICT OFFICES AND REPRESENTATIVES—Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, St. Paul, Pittsburgh, Roanoke, Sanford, N.C., St. Louis, Los Angeles, San Francisco, Seattle, Montreal—A. C. Leslie & Co. PRODUCTS INCLUDE—Steel Products in Carbon, Copper or Alloy Analyses : : Sheared Steel Plates : : Hot Rolled Sheets and Strip : : "A.W." Rolled Steel Floor Plates : : Billets, Blooms and Slabs : : "Swede" Pig Iron : : Reading Cut Nails.

Developing Unit

The Harry W. Dietert Co., Detroit, is marketing a photographic plate or film "Developing Unit." This unit possesses a pivoted top table which is rocked by means of a motor driven cam. The developing, stop, hardening and fixing solutions are automatically controlled at a temperature of 70 deg. F. by means of water circulating through a copper coil attached to bottom of the rocking table. The circulating water is taken from the city supply line and passed through a chamber containing an electric heater and a 70 deg. F. thermostat insuring that the circulating water is at 70 deg. F.

When the Developing Unit is used, the plate or film may be processed within 2 mins. time uniformly without grain growth. This unit is of particular aid in processing plates or films in spectrographic and metallographic laboratories.

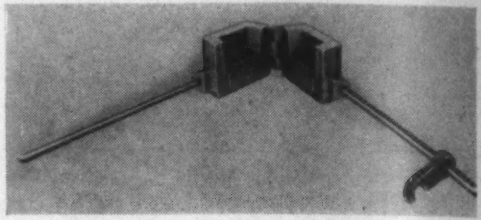
A Smoothset Mortar

A leaflet describing "B&W Smoothset Mortar" has been issued by The Babcock & Wilcox Co., 85 Liberty St., New York. This mortar was especially developed for use with highly porous insulating firebrick, which are often difficult to lay with the mortars and clays generally available, since the water is drawn from the bond rapidly and insufficient time is allowed for proper placing of the brick. B&W Smoothset Mortar, with a high degree of water retention, and a high bond, is said to meet this condition. Service temperature limit is 2850 deg. F. According to the manufacturer, this new mortar is smooth, plastic, cold-setting, and easy to trowel. No heat is necessary to develop its bonding strength, which is greater than the strength of insulating firebrick and equal to many firebrick, so that monolithic structures will result from its use.

Cast Metal Specimen Mold

The cast metal mold is used to form test specimens of either non-ferrous or ferrous metals. It is made of heat resistant cast iron and is provided with two steel handles to facilitate its operation. The molten metal poured into the pouring basin of the mold forms four test specimens ⅛ in. in dia. and 1 in. long. Two of these may be used for spectroscopic analysis and the other two may be broken into pieces ¼ in. in length and weighed for either carbon or sulphur determinations. These chill test pieces burn more readily and form a more accurate sample than borings

Through the use of the Cast Metal Specimen Mold a test specimen for either spectrographic, carbon or sulphur analysis may be made ready for the laboratory in less than 1 min. It is also claimed to eliminate considerable work and time, especially in the case of hard irons which must ordinarily be annealed prior to attempting to drill the sample or which must otherwise be crushed to suitable size. This mold has been developed by the Harry W. Dietert Co., 9330 Roselawn Ave., Detroit.



Protect-O-Metal

"Protect-O-Metal" compound, manufactured by G. W. Smith & Sons, 2016 East Third St., Dayton, Ohio, comes as a valuable aid in the welding and die casting industries. It saves money, time, and energy, by checkmating the destructive elements of friction, corrosion and adhesion, ever-present in high-heat processes, it is said. This new compound is claimed to prevent corrosion and the collection of spatter on the surface surrounding the weld, thus eliminating the costly operation of weld cleaning. Just brush Protect-O-Metal on the surface to be welded. After welding, wipe surface with cloth or wash with water and all spatter and surface oxides are removed. Besides this Protect-O-Metal forms an ideal priming coat for a paint finish if desired. It is said to prevent formation of rust on steel after welding and will not harm the surface of any metal; it does not produce carbon. When Protect-O-Metal is sprayed or brushed (preferably sprayed) on a die, it is said to form a perfect heat resistive coating, prevents the molten metal from sticking to the solid metal and allows perfect ejection of the castings. Protect-O-Metal coated on a die, core pins will not break off, be worn undersize, nor gauld due to the shrinkage of the molten metal, as commonly occurs particularly in the casting of aluminum.

The preservative qualities of this patented compound will multiply many times the ordinary life of a die. It is claimed equally effective for deep drawing dies, permanent molds, and drop forging.

Electrolytic Manganese

A new metal has been added to the small group of basic elements now employed in industrial alloys and offers the metallurgist an entirely new field to explore. Electrolytic manganese analyzing 99.9%+ is now being produced on a commercial scale by Electro Manganese Corp., at its Knoxville, Tenn., plant.

This material is said to make possible the utilization of manganese in many alloys in which it is already used, without, however, the simultaneous addition of other elements such as carbon, aluminum and silicon, which have been present in heretofore commercially available forms of manganese. It also offers distinct advantages in bringing low carbon steels up to manganese specifications without the necessity of preliminary over-oxidation before additions, to keep carbon and silicon within limits.

Of special interest is the new field opened by the use of electrolytic manganese as a base for an entirely new series of alloys, particularly with non-ferrous metals.

Control that CASE DEPTH
with efficient—economical
Du Pont CASE HARDENING Salts

Shallow or deep cases . . . you can obtain the right case hardening salt from du Pont to meet your individual requirements.

These salts are uniform with a guaranteed cyanide content. They provide a wide operating range and the utmost in economy.

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LIQUID BATH PROBLEMS
Tell us about them. Our research and field staff will gladly help you find the answer.

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E. I. DU PONT DE NEMOURS & COMPANY (INC.)
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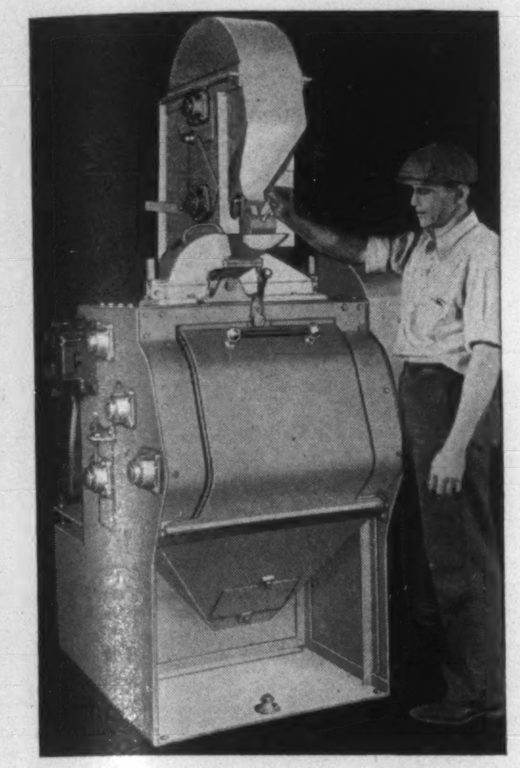
Small Capacity Wheelabrator

A new 15 by 20-in. airless Wheelabrator Tum-Blast, having an operating load capacity of 1 cu. ft. is now being marketed by the American Foundry Equipment Co., 555 S. Byrkit St., Mishawaka, Ind. It is said that this size machine is particularly well adapted for use in foundries (ferrous and non-ferrous), heat-treat shops, forge plants, stamping shops, and other plants cleaning and finishing comparatively small products in limited loads. Another use for the machine is in the large industry where a small auxiliary machine is required for the smaller jobs.



This Tum-Blast performs its cleaning function without compressed air by using a Wheelabrator centrifugal abrasive blasting unit which throws metallic abrasive, under perfect control, upon the work being cleaned or prepared. The operation of this model is very similar to that employed in the larger size Tum-Blasts. One 3-hp. electric motor provides power for all operating units, including the Wheelabrator, the abrasive elevator and the mill drive.

Weld Recorder

Because the numerous variables affecting the quality of spot welds are not under constant control, the General Electric Co., Schenectady, N. Y., has developed a weld recorder to record and indicate these variations. The weld recorder acts as a recording instrument, signaling device, and lockout control which measures the electrical input to the spot-welding machine for each spot weld.

With the increased use of welding and the increased rigidity of specifications, sound, dependable welds are a primary requirement. Spot welding is now being used extensively on structural members of aircraft, rail cars, automobiles, buses, trucks, and trailers. Each of these structures is subjected to vibrational stresses of considerable magnitude, and in some of them certain parts must be airtight and gastight. Here, the failure of a single weld might be fatal.

The new weld recorder is so designed that when the electrical input to the welder (I^2t) varies sufficiently to cause a defective weld, a bell gives a continuous audible signal, and the weld-initiating circuit is automatically opened, preventing subsequent welding until a push button is pressed. In addition, the recorder chart indicates visually that the weld was not within the preset allowable limits for proper welding and shows whether the heat was above or below normal. The Edward G. Budd Mfg. Co., Philadelphia, is using 40 of these new weld recorders to avoid unknown faulty welds in the "shot welding" of airplane fuselage and rail car structures.

Stock Bronze Bearings

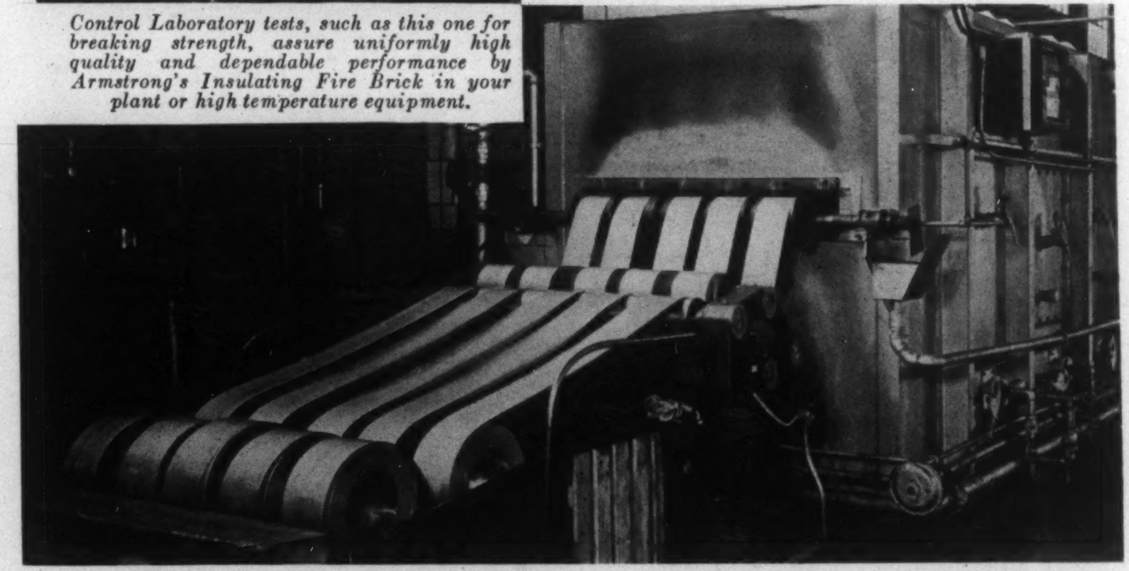
A slide rule, which lists over 800 sizes of standard stock bronze bearings, has been prepared by the Johnson Bronze Co., New Castle, Pa. The company has found that, in a great many cases, engineers, designers and draftsmen were either not permitted or found it inconvenient to keep a copy of the company's regular catalog on their desks. The slide rule has therefore been prepared so that this information can be available with a saving of time and money. The slide rule can be obtained from the company by requests on business letterheads.

Rotary Air Grinder

The Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, has recently put a new 5½ in., 17 oz., Rotary Air Grinder on the market. For complete data and specifications of this new "Thor" tool, the company has issued a circular. It gives the uses for the new tool (which is called "Bantam") and depicts it in many interesting close-up action photos. All grinding wheels and accessories available are pictured and priced to give an idea of the versatility of this tool. This circular is colorful and instructive and gives the pertinent information in an easy to read style. It can be obtained by writing the company and requesting circular P20.

Control Tests

guard efficiency of
Armstrong's
Insulating Fire Brick



Control Laboratory tests, such as this one for breaking strength, assure uniformly high quality and dependable performance by Armstrong's Insulating Fire Brick in your plant or high temperature equipment.

This gas-fired steel strip furnace, operating at 900° to 1350° F., is one of many different types of furnaces built by Surface Combustion Corporation and insulated with efficient Armstrong's Brick.

CONTINUOUS testing in the laboratory and exceptional performance records in the field have proved time and again that Armstrong's Insulating Fire Brick are ideal for most types of furnace design.

These brick have all the qualities so essential to efficient, high-temperature insulation. Their low thermal conductivity, high physical strength, uniformity, low shrinkage, and high refractoriness mean big savings in fuel consumption, construction costs, and increased production quality and volume.

Armstrong offers a complete line of high temperature insulation. Write for samples, prices, and literature. Armstrong Cork Company, Building Materials Division, 982 Concord St., Lancaster, Pennsylvania.

Armstrong's
HIGH TEMPERATURE INSULATION
INSULATING FIRE BRICK · HIGH TEMPERATURE BLOCK
PLASTIC CEMENTS · DIATOMACEOUS EARTHS

An Engraver and Electric Etcher

A new bench-type pantographic machine for general industrial engraving work on all materials, and electric etching on soft or hardened steel, has been introduced by H. P. Preis Engraving Machine Co., 157 Summit St., Newark, N. J. Separate heads, quickly interchangeable, are used for the two classes of work.

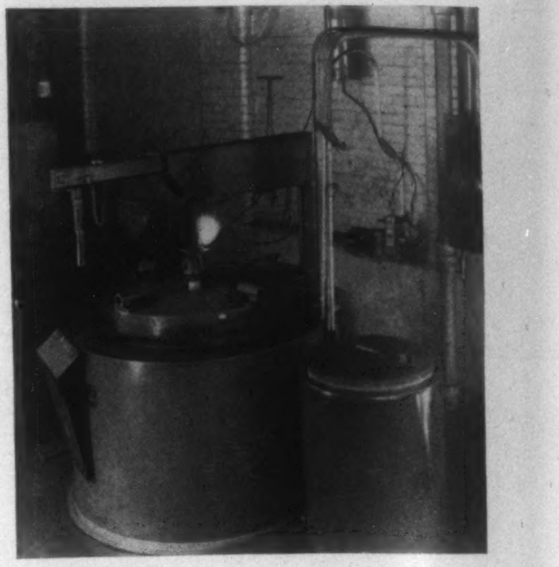
On engraving work, depth of cut is controlled, independent of the depth of master characters, by a micrometer adjustment mechanism on the engraving head. Movement of the engraving cutter, to and away from the work, is controlled by a cam-action drop lever, thus eliminating the necessity of raising and lowering the pantograph. Either raised or sunk engraving can be produced. For engraving on uneven surfaces, on slightly concave or convex surfaces, or on objects varying in thickness, an automatic depth-of-cut regulator is furnished.

On electric marking, contact of the etching point with the work is controlled by a sensitive spring pressure. The etching point may be removed from its fixture and used as a hand-etching pencil for rough or freehand marking. An electrical transformer provides three or more voltage stages for various depths of marking.

The compactness of this unit, and the fact that it can be plugged into any light socket for instant use, are features that should, it is claimed, recommend it for a wide range of industrial and commercial work. Illustrated folders on the machine, and on master copy type for use therewith, will be sent upon request to the manufacturer.

An Automatically Controlled Carburizing Furnace

A carburized case of any specified depth in the carburizing range is claimed to be secured uniformly and with remarkable speed and certainty in the new "Homocarb Furnace." With this equipment, the heat-treater can follow carburizing specifications accurately—for there are separate and fully-automatic controls for temperature and for amount of carburizing medium. These controls permit the operator to vary any factor or factors while holding the rest constant, thus making possible marked improvement in successive batches of parts until the conditions that give ideal case structure are determined. These conditions are then automatically secured in batch after batch, setting a new standard of excellence for high-speed, mass-production work.



There is no packing of work for Homocarb carburizing; parts are put into the furnace bare, for exposure to the Homocarb gas. Large parts are loaded either in the furnace basket or on fixtures; small parts are simply dumped into the basket, or into trays.

This equipment applies to the carburizing process the unique Homo method of short-path, forced convection. It takes Homocarb fluid—a specially-prepared hydrocarbon oil—and cracks it, inside the furnace, into a gas rich in carbon and uniform in chemical analysis. A big, high-pressure fan, located immediately below the work, swirls this gas, at full carburizing temperature, directly into every crevice of the load and to every surface of every piece. The carburized case develops at a rapid, predictable rate that is practically the same for parts of all sizes, regardless of the density with which they pack into the furnace.

Homocarb equipment is not only easy to operate and maintain, but is compact, requires little floor space. It consists of the Homocarb furnace proper, and a Micromax recording controller on a panel with other control accessories, all factory-wired and ready to operate. A separate cooling unit is supplied for applications requiring slow cooling from carburizing temperature. For detailed information ask for Catalog T-623, issued by Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania.

A Proportioning Low-Pressure Oil Burner

The Hauck Mfg. Co., 124 Tenth St., Brooklyn, announces a new proportioning low pressure oil burner. It is described as an "all in one" burner which does not require extra valves and is all ready to hook up to temperature control equipment for accurate combustion and temperature control.

It is claimed that (1) it automatically and accurately proportions all the primary and secondary atomizing air and the oil flowing through the burner from minimum to maximum capacity; (2) maintains the desired furnace atmosphere; (3) produces the greatest turndown ratio; (4) combines a straight line flow oil control valve with a straight line flow air control mechanism in a single, compact, rugged unit; (5) is easy to install; (6) is simple to operate and (7) has straight line flow characteristics and is used with other straight line flow valves.

MEMO . . .

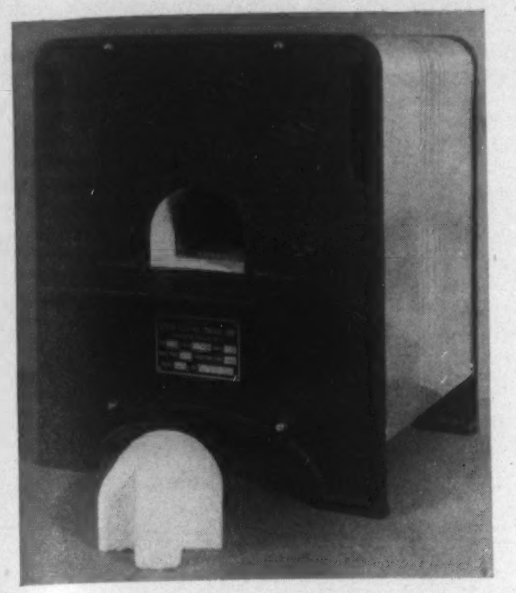
Regarding that furnace problem --- write The Electric Furnace Co., Salem, Ohio --- they have a reputation for solving difficult production furnace problems --- they build both electric and fuel fired equipment, and will recommend the best type for the job. Better write or 'phone them today.

E. F. C.

The Electric Furnace Co., Salem, Ohio, Builds Gas Fired, Oil Fired and Electric Furnaces—Furnaces For Any Product, Process or Production.

A Laboratory Electric Furnace

The new Harper electric laboratory furnace, built by the Harper Electric Furnace Corp., Niagara Falls, N. Y., is claimed to answer every need for convenient, accurate research and laboratory testing. The furnace is described as quick heating in that it heats up to 2500 deg. F. in 1 hr.; as compact because it requires space only 17 in. high, 14 in. wide and 12 in. deep; as having a wide temperature range of 1000 to 2500 deg. F.; and as quality-built assuring satisfactory, long term service under most exacting conditions. Other claims point out its flexibility, noiselessness, efficiency and simplicity. It is designated as the "HL-3 Laboratory Furnace."



New Koroseal Paint for Corrosive Conditions

Again extending the use of its recently introduced synthetic elastic, Koroseal, The B. F. Goodrich Co., Akron, Ohio, announces a new Koroseal paint, designated as "No. 495 Korolac," the name covering solutions of the plasticized poly-vinyl chloride whose basic materials are coke, limestone and salt, and which was developed in the Goodrich laboratories. A Korolac primer for use with the new paint is also introduced.

The new paint is claimed to give a semi-glossy black finish and is recommended wherever extremely corrosive conditions disqualify any other kind of paint or coating. Applied to metal surfaces after they are prepared for any other kind of paint or lacquer, the primer forms a strong bond between the Korolac and the metal itself. Korolac No. 495, when thoroughly dry, is said to withstand all acids, alkalies and salts in the concentrations commonly met with in industry, up to temperatures of 150 deg. F. It is not affected by chrome, nickel, cadmium, zinc, copper, brass, silver or tin plating solutions, nor are such solutions contaminated or fouled by the paint when it is thoroughly dried.

Ordinary atmospheric conditions have no effect on the paint. It is extremely moisture resistant. The dried film is hard and resistant to abrasion, yet sufficiently elastic to conform to contraction and expansion of the support. Both the primer and the paint can be applied by brushing or spraying. One of the largest automobile manufacturers is reported now using this paint for coating various structural metal parts, and fume ducts in and around pickling and plating departments.

New 24 Kt. Gold in Liquid Form

The Mark Weisberg Laboratories, Providence, R. I., announce the development of a new certified 24 kt. gold in liquid form for electroplating solutions. This development is said to fill a long-felt need in the jewelry and novelty industry for a standardized gold electroplate. Among its many advantages are uniformity of color, high efficiency, and exceptional throwing power.

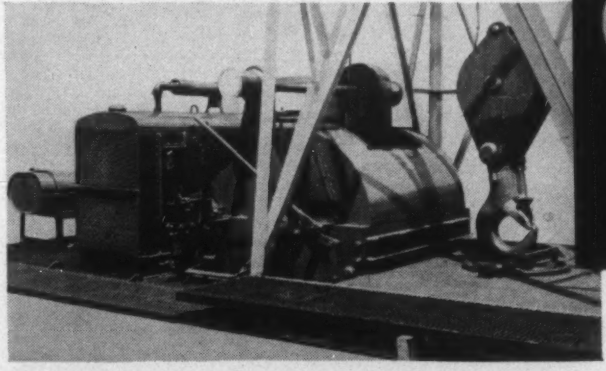
Available with this new gold are special reagents for preparing electroplating solutions and alloys for pink, red, and green solution.

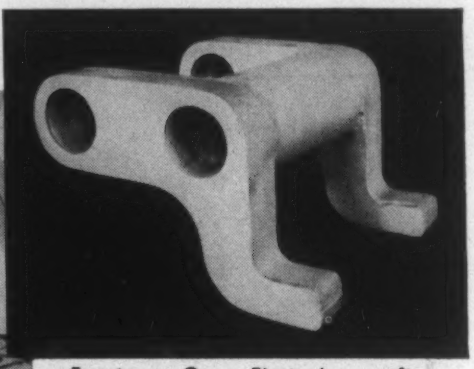
Colalloy Chromaloy Stainless Metal

For those who seek Colalloy high surface finishes (satin or mirror) that will not oxidize or tarnish, "Chromaloy" appears to be a most suitable light-weight, rust-proof, low cost, stainless metal. This recent development is claimed to create a hard, close-grained, non-porous protective surface which has unusual adherence and homogeneous molecular affinity for the base metal. Not only does it afford an added protection against corrosion of the base metal, but serves decoratively as well. On a number of tests recently completed it is reported that over 630 hrs. of the Navy salt spray test showed little or no effect either on the metal or its surface finish.

The surface of Chromaloy No. 4 is described as a soft velvety satin color, somewhat similar in appearance to the usual No. 4 finish on 18 and 8 stainless steel. The surface of Chromaloy No. 8 is a high deep chrome mirror color, somewhat similar in appearance to the usual No. 8 finish on 18 and 8 stainless steel. Both Colalloy Chromaloy Nos. 4 and 8 are available in a wide variety of sheet sizes and gages, seamless tubes and pipe, rod, angles and castings. Bulletin No. 81539 and small sheet samples of the materials are available to interested firms, from the Colonial Alloys Co., Colonial Philadelphia Building, Philadelphia.

Typical of housings and structural work fabricated with Genex is this portable drill rig built by Brauer Machine & Supply Co., Oklahoma City.





Easy to use, Genex Electrodes are often employed in making small units to replace castings, such as this one built by The Dorr Company, Denver.

KEEP YOUR WELDING COSTS DOWN WITH MUREX

GENEX

The SPEEDY, EASY-TO-USE ALL-POSITION ELECTRODE FOR STRAIGHT POLARITY OR A.C. WELDING.

Designed for welding in any position . . . flat, vertical, or overhead . . . and to readily bridge gaps where assembly fit-up is imperfect, Murex Genex Electrodes have several outstanding features which make them highly economical in operation. They are used at higher currents, which steps up welding speed. They burn with less spatter; less smoke, and so provide better visibility of the arc and the molten pool of weld metal. The slag is easy to remove and does not cling to the edges of the weld, even on heavy fillets. In multiple pass work, beads can be deposited on top of each other without cleaning away the slag between passes.

Send for complete information, or ask to have a representative call and show you what these electrodes can do.

METAL & THERMIT CORPORATION
120 Broadway, New York, N. Y.
Albany • Chicago • Pittsburgh
So. San Francisco • Toronto

In marine work, Genex speeds work where lap welds are required on bulkheads and hull plating.

MUREX HEAVY COATED Electrodes
A COMPLETE LINE FOR EVERY WELDING APPLICATION

Investigate Thermit Welding, too—in use since 1902 for heavy repair work, crankshafts, etc.

Controlling Welding Time

Ability to positively control welding time to a half cycle of current on any resistance welder is provided by a new weld timer just announced by Weltronic Corp., 2832 E. Grand Blvd., Detroit. Built as a separate unit the timer may be adapted to virtually any standard resistance welding machine. It is recommended particularly for welding thin section stainless steel, aluminum, brass screen, copper lugs and similar applications where unusually high heat and closer control of welding time than offered by conventional timers is essential.

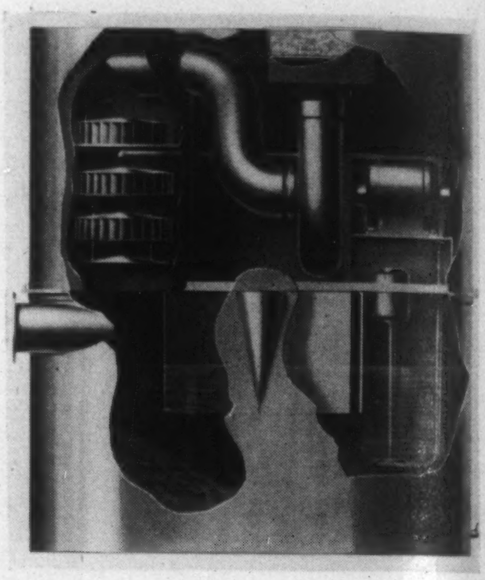
The new timer provides a full positive half-cycle in order to permit use of the highest heat in the shortest possible time. Known as "Model 90-1" the timer is available in 220 to 550 voltages with frequencies of 25, 50 and 60 cycles. Amperage range of 150 to 600 is also available.

Use of "split-cycle" timing heretofore has been restricted to complete new welding machines having the half-cycle timer feature as an integral part of the welding machine. In addition to "split-cycle" timing, the new unit is said to reduce operating costs for equipment to which it is applied. It consists, essentially, of only 2 moving parts (the relays) in addition to one electronic and one rectifier tube, all of which are panel mounted and enclosed in a hinged-cover case. Interesting is the fact that the relay closes on the minus half cycle permitting the timer to fire on the positive half cycle.

Midget Multi-Wash Dust Collector

The Claude B. Schneible Co., 3951 W. Lawrence Ave., Chicago, has placed on the market a new portable type wet method dust collector known as the "Schneible Midget Multi-Wash Collector." This unit functions identically the same as the standard type Schneible Multi-Wash Dust Collector, except that it is made only in 6 small sizes with a range of from 300 to 1500 c.f.m. and is a complete self-contained wet dust recovery system.

The Schneible Midget is designed for the collection and disposition of dust and fumes arising from isolated operations or machines and equipments that cannot economically be tied into a central dust collecting system. It is likewise claimed ideally applied to dust suppression from all abrasive grinding, sawing, tumbling, pulverizing, milling, spraying, heat-treating and other dust and fume creating operations.



One of the 6 sizes is applicable to from 1 to 5 machine operations depending, of course, upon the nature of the process or operation and the amount of ventilation required. The unit is compact, light, entirely self-contained and continuous and fully automatic in operation. Fouled air is drawn into a miniature scrubbing tower where dust and fumes are scrubbed out by spray walls and become impinged on a multiplicity of curved wet vanes arranged in several tiers. Impinged matter is washed down to a sludge chamber by the turbulent action of water introduced above the impingers. The washed air next passes through an entrainment separator to remove excess moisture and is then delivered to the plant atmosphere passing through a metal-wool diffuser and sound deadener as it leaves the unit. There are no bags or screens to clean out and no dry dust to handle.

The sludge is settled in a dewatering compartment from where it is drawn off for disposition occasionally, the water or other washing medium being recirculated over and over. As only a small amount of water is needed, it can be put in by hand, no piping being required. Motors are completely sealed from dust and moisture and the manufacturer claims the unit has a comparatively low operating and maintenance cost. The unit is a completely self-contained dust collecting system, ready to plug into electric outlets.

Dryer

The Harry W. Dietert Co., Detroit, is now marketing a Dryer for rapidly drying photographic plates or films as used in metallographic and spectrographic laboratories. A film or plate may be dried within 2 mins., thus avoiding the usual ½-hr. waiting time before the information on the film or plate may be interpreted and put to use.

The Dryer consists of a sturdy constructed electric motor driven blower. The air is heated to a predetermined temperature by means of an electric heater. The film or plate is held vertically in the Dryer and dried rapidly by the high velocity heated air current sweeping past the surface of the film or plate.

FROM ORE TO METAL

The Story of St. Joe Electro-Thermic Zinc No. 11 of a Series

CASTING ST. JOE ZINC

At the rate of once every hour during the twenty-four hours of the day and night, the ladle in this picture is filled with 1400 pounds of molten zinc tapped from each of the continuous vacuum type condensers developed for the electro-thermic furnaces at Josephtown.

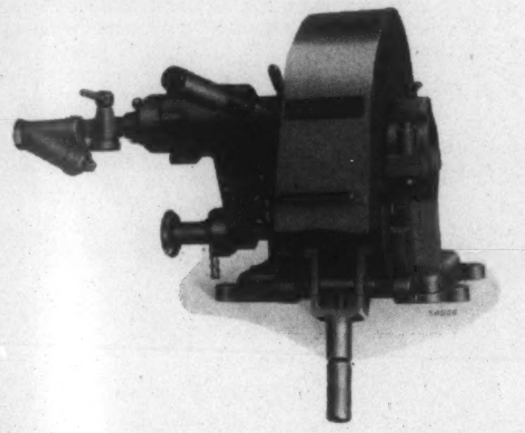
Each ladle represents a "lot", indicated by a number stamped on every slab, and for each lot a laboratory control sample is taken and analyzed.

Josephtown produces High Grade, Intermediate, and Prime Western grades of zinc. The only concentrates treated by the smelter come from the New York State mines of the St. Joseph Lead Company. This means a constant quality of furnace charge, and a very uniform quality of slab zinc.

ST. JOSEPH LEAD COMPANY
250 PARK AVENUE • NEW YORK
ELdorado 5-3200
PLANT AND LABORATORY, JOSEPHTOWN, BEAVER COUNTY, PENNSYLVANIA

Drill Steel Cutter and Shank Grinder

Ingersoll-Rand, 11 Broadway, New York, announces a new, Size 500, combination drill steel cutter and shank grinder. Designed to handle solid or hollow steels up to and including 1¼ in. hexagon, round or quarter octagon, it cuts the steel cleanly and squarely in only a few seconds without burning. A quick acting, self-locking vise holds the steel rigidly on both sides of the cut.



The unit can be readily changed from a cutoff machine into a shank grinder by removing the cut-off wheel and substituting a grinding wheel. As a grinder it can be used for squaring up striking faces of the shanks of drill steel, moil points, chisels and the striking end of rock drill pistons. The machine is powered with an Ingersoll-Rand "Multi-Vane" Air Motor.

Insulating Firebrick

The Babcock & Wilcox Co., 85 Liberty St., New York, has recently introduced a new insulating firebrick, designated "K-16." Representing a radical improvement in heat-insulating materials, the K-16's now make available for the first time a product that is said to have the stability of a fired-clay refractory, and yet weighs less and has insulating values comparable with or superior to unfired insulating materials.

Made of special Georgia kaolin by an exclusive process, the manufacturer states that these insulating firebrick retain their structure, show negligible shrinkage, and can withstand loading without deformation at temperatures up to 1600 deg. F. for direct exposure and 2000 deg. F. (interface) for backing up. The average weight is only 1.1 lb. per 9-in. straight or approximately 19 lb. per cu. ft. An indication of their effectiveness is shown in the case of a wall of 9-in. dense firebrick backed up with 4½ in. K-16. The heat-flow loss in such a wall is 76 per cent less than without the backing up.

A Rust Preventative Coating

The Estox Products Co., 151 Brewery St., New Haven, Conn., has developed a product which it describes as a new rust preventative and protective coating for steel, brass and other metals, which it is claimed will protect the surface for a period of 9 to 12 mos. either in storage or shipment.

This product, known as "Metaseal 494," is the result of 10 yrs. of experimenting to compound a protective coating that would protect metal parts from the salt air and exposure encountered in shipping abroad. Metaseal 494 may be applied by dipping, spraying, brushing, etc. It can be removed by bathing in a thinning solution and then washing in any standard commercial cleaning solution.

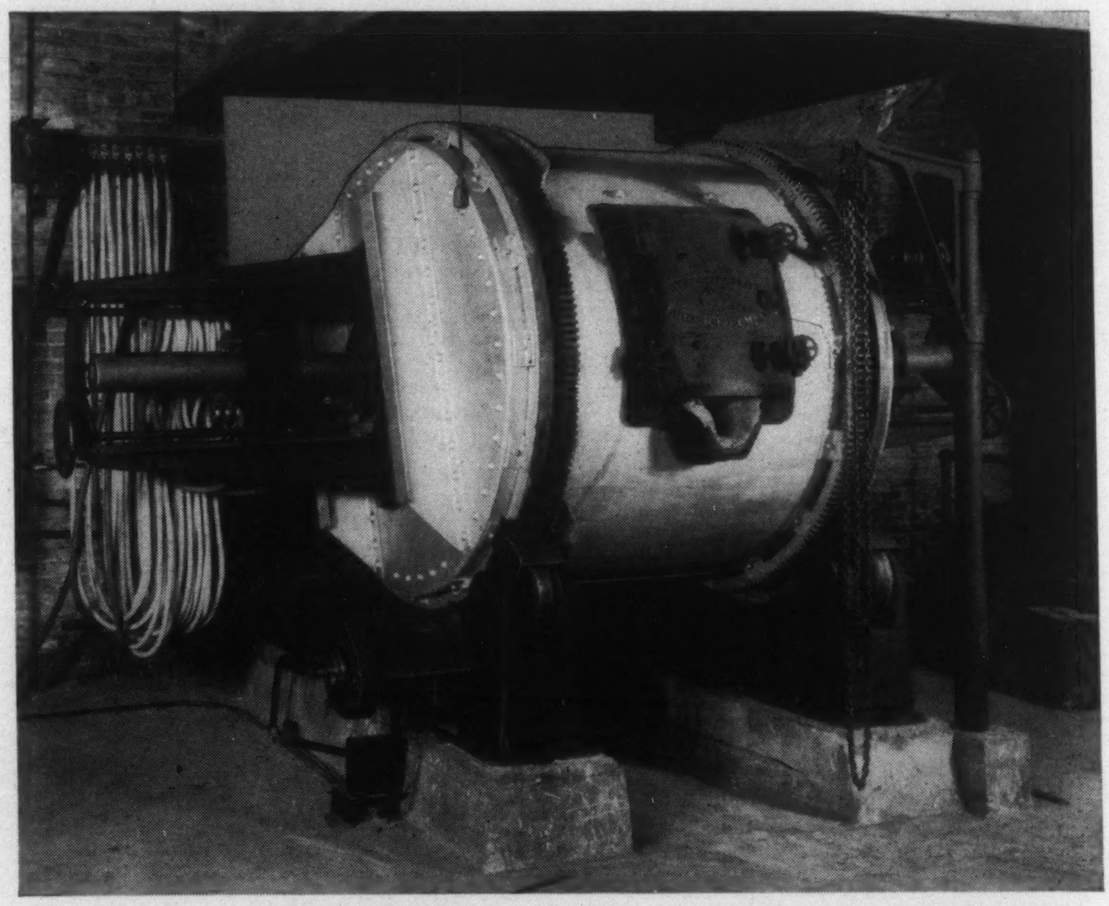
In addition to giving complete protection of clean metal parts, in either the ground, forged, machined, etc., state, it is claimed that Metaseal 494 is inexpensive to use due to the generous area which may be covered per gallon. It is said to be practically invisible when applied.

Refractory Radiant Tubes

The Gas Machinery Co., Cleveland, has developed and put on the market a refractory radiant heating tube which is claimed to be commercially practicable, and safe for temperatures considerably in excess of 2500 deg. F.

The special refractory of which this tube is built is said to have a conductivity 10 to 12 times that of fire clay refractory and, as a transmitter of radiant heat, to be comparable to the conventional alloy tube. The tubes are fired with low pressure natural gas, special diffusion type burners being employed. The design is such that uniform temperature distribution can be maintained in each tube from end to end of a furnace, over a wide range of operating temperatures. Sub-atmospheric pressures are maintained within the tubes so that there will be no possibility of leakage from the tubes to the heating chamber under normal operating conditions.

The tubes are horizontally applied in order that any tube or combination of tubes can be shut off as required, in order to provide positive control of heat application from top to bottom of the charge. As a usual procedure, when the charge approaches the soaking temperature, the upper tubes are shut off and heat application is confined entirely to the lower portion. A considerable degree of flexibility of heat application is therefore possible for a range of annealing cycles.



TAP A SPECIAL HEAT EACH HOUR

—and make money doing it!

Almost any commercial alloy—ferrous or non-ferrous—can and is being melted in the Detroit Rocking Electric Furnace.

Fast, simple, flexible and efficient, a Detroit Furnace can profitably run a distinctly different charge every hour. A Detroit gives very low metal loss, more accurate control over time and temperature and perfect control of analysis, thus assuring a superior quality product. Today more than ever before Detroit Electric Furnaces are economically meeting the needs of modern specialized engineering requirements.

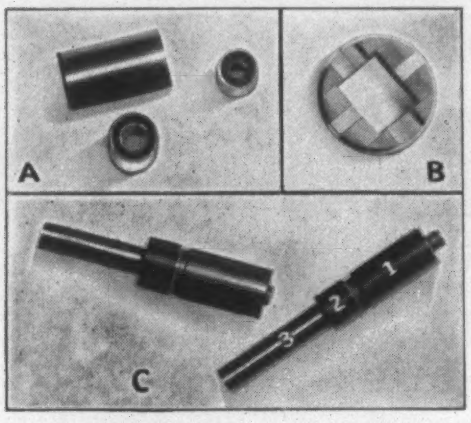
An efficiently operated jobbing or production foundry can make money—and plenty of it—with a Detroit Furnace. Write us today for complete facts and prices.

DETROIT
ROCKING ELECTRIC FURNACE
DIVISION OF KUHLMAN ELECTRIC CO., BAY CITY, MICH. AGENTS IN 40 CITIES

Wear Resisting Parts of Kennametal

McKenna Metals Co., 158 Lloyd Ave., Latrobe, Pa., announces that Kennametal is now available in almost any desired shape for use in parts subject to unusual wear or for gages which must hold their accuracy. Kennametal is an alloy containing the new intermetallic compound, tungsten-titanium carbide. Shown in the illustration are a few of the many wear-resisting parts now being made of Kennametal.

Fig. A illustrates three sizes of extrusion dies for coating steel welding rods with abrasive flux. In a recent test, a Kennametal die extruded more than three times as many pounds of electrodes as the best sintered carbide die previously used, with the same amount of wear. Fig. B is a Kennametal die for pressing articles of refractory aluminous oxide, used in the radio industry. The wear-resisting properties of Kennametal make it ideal for dies used in pressing and forming abrasive ceramic parts, where it will often give 50 times more service than high-carbon, high-chrome dies. Fig. C shows progressive type plug gages for measuring steel bores, such as ball bearing races. A cylindrical shell of Kennametal (1 and 2) has been silver soldered to a steel handle (3). The Kennametal section "1" at right of relief groove has been accurately ground to 0.2495 in. dia.; and section "2" at left to 0.2500 in. dia. In testing a bored hole, section "1" will slip in but section "2" will not, thus measuring size to within 0.0001 in. accuracy.



Kennametal is also used in follow rests, lathe and grinder center nibs, oil well pump valves, drill tips for masonry, stone, etc., jig drill bushings, wire coiling tools, sand blast nozzles, tips for tongs on glass working machinery, and many other wear-resisting parts. The company will gladly cooperate with interested manufacturers in adapting Kennametal for special applications.

Air-Oil Ratiotrol for Oil-Fired Furnaces

Industrial research has now perfected a definite control over the atmospheric conditions in the heating chamber of the oil-fired furnace. The advantages and possibilities of such control has been widely demonstrated in the gas-fired furnace.

This new control is the "Air-Oil Ratiotrol" and has been developed by the North American Mfg. Co., Cleveland. The Ratiotrol, it is said, has been tested in the laboratory and under actual plant operating conditions for several months. It has made definite savings in oil consumption and has maintained a constant atmosphere, giving protection to the steel being treated in the furnace.

The Ratiotrol's very simplicity of operation is pointed to as one of its most interesting features. It accurately proportions the flow of fuel oil and its combustion air by controlling pressures and making them dependent upon each other. The air pressure alone becomes the dominant factor while the number of burners and their individual settings have no effect on the operation. The Ratiotrol is said to maintain a constant atmosphere despite fluctuation of oil or air pressure, despite varying rates of fuel input or the manipulation of individual burners.

A 200-Ampere Welder

Not only does the Harnischfeger Corp.'s (Milwaukee) "P&H-Hensen Model WA-200" (square frame) welder readily adapt itself to production-line manufacture, thereby allowing its slow first cost, but it is said to provide extremely simple adaptation for use in parallel hookups. This feature is claimed to be of most importance in plants where welding jobs requiring large amperages are frequently met, but where the run-of-the-mill job is one calling for welding heats up to 225 amps. Thus it is not necessary to stand the expense of a large welder which is used but seldom.

These new square-framed, extremely compact welders, which occupy only 3½ sq. ft. of floor space, are pointed to as giving a welding range from 40 to 225 amps. Where a wider range is desired, as is the case in many plants for an occasional job or so, they may be mounted one on the other and hooked in parallel. Such an installation provides two 225-amp. welding services, or one 450-amp. welding service. Thus installed, they may be used singly or in parallel, connected or disconnected at will. Because of the smaller size of the WA-200, it may in all cases be brought closer to the work to relieve aisle congestion and permit the use of shorter cables for maximum efficiency at the point of work. Cable costs can therefore be also reduced. These units can be stacked one above the other for parallel hookups without the need for expensive structural frame work or other support.

For further information on these new welding services, get in touch with the manufacturer, the Harnischfeger Corporation of Milwaukee.

Photoelectric Limit Switch

To reduce maintenance on limit switches in the heavier industries, Photoswitch Inc., 21 Chestnut St., Cambridge, Mass., announces an addition to its line of controls—"Photoswitch Electric Eye Limit Switch."

This low cost control is a simplified photoelectric unit, utilizing rugged construction, suitable for installation in heavy industries where exacting conditions of vibration, humidity, and high temperatures are encountered. In controlling and limiting the motion of heavy objects such as billets and sheet steel, cranes and hoists, red hot rods, etc., there very often are heavy maintenance costs connected with mechanical limit switches. By substituting light beam control, this maintenance cost is said to be completely eliminated.

Resilient Sheet

The resilient sheet protected by U. S. Patent No. 2,158,929 is a sheet of metal or related material in which holes are punched according to a regular pattern. The strips or elements between the perforations are then corrugated or curved so that the sheet has a cross-section. When tension is applied to the sheet in its plane or transversely to it, the corrugations yield and the sheet stretches somewhat; since tension in any direction may be resolved along coordinates parallel to the corrugated elements, it is said to be evident that the sheet is stretchable in any direction, and that the "stretch" is far in excess of the normal elongation under stress of an untreated sheet of the same material.

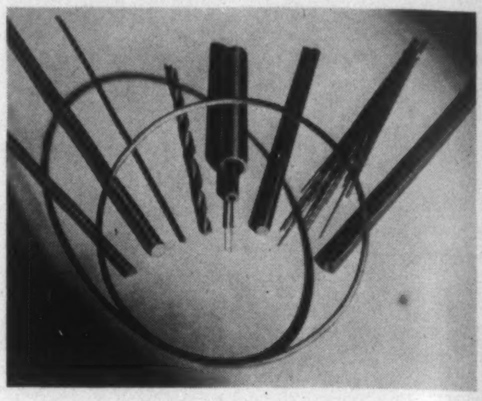
Since such a flexible sheet is claimed to be an obvious substitute for bulky coiled-wire spring assemblies, it is proposed to use it for seats, backrests, etc., in furniture construction, and thus to save space and weight and to eliminate the costs of assembling and installing springs by hand. This application is especially useful in the manufacture of washable outdoor and hospital furniture, and of lightweight furniture for railways and aircraft. Other applications readily come to mind.

The manufacturing costs are negligible, since the process consists of a simple punching operation to perforate the sheet, followed by a rolling operation to make the corrugations; the two may be combined into one by the use of specially designed rollers.

For further information, consult Leonid A. Dunajeff, Commercial Ingredients Corp., 551 Fifth Ave., New York.

Extrusion Process For Cemented Carbide

Carboloy cemented carbide now can be produced in the form of tubing, spirals, and round or shaped bars by means of an extrusion process, it is announced by Carboloy Co., Inc., Detroit. Available in lengths up to 20 in. and within a diameter range of from 0.015 to ⅜ in. O.D., these rods, spirals and tubes are considered a distinct inovation compared to previous practice. Formerly such parts were available only within an extremely limited size range and it was necessary to perform a large part of the shaping operation manually. With the new process now employed, the Carboloy parts are formed directly into the shapes desired, eliminating most of the customary hand forming operations.



The Carboloy tubing now produced is of especial interest. This can be made as small as 0.060 in. outside dia. by 0.030 in. inside dia., leaving a wall thickness of 0.015 in.

Particularly interesting are Carboloy rods, etc., which can be bent to various shapes. The 5 in. dia. ring illustrated was produced through this process. It consists of a round rod curved to form a ring, with the ends joined together.

These two processes, making available a range of shapes in sizes heretofore considered economically or mechanically impractical, will, it is felt, tend to uncover numerous fields of application heretofore not regarded within the realm of practical carbide use. Although the processes have by no means reached the stage of maximum utilization, and in some phases are still considered in the process of development, many Carboloy products, such as core bushings for ceramic dies, wire guides, valve needles, triangular glass drills, textile guides, etc., are now being produced by these methods.

Atomic Welding Liquid and Rod

A most satisfactory method to atomically weld stainless, low carbon and practically all the ferrous alloys has recently been made available, it is said. Gages from 0.005 to 0.050 in. lend themselves more readily to this method of securing an atomic welded bond, without the use of welding apparatus or experienced welders.

The method employed in this welding is described as a comparatively simple one which, when mastered, lends itself to very fast operation in production work, at comparatively low cost. "Colalloy Atomic Welding Liquid" is simply brushed onto the metal at the points where the welding is to take place, rod applied, then subjected to heating at about 450 deg. F. In the matter of seconds, the weld is completed. The lighter the gage of metal, the faster the action, and the stronger the weld, it is claimed.

The bond is atomic, not just adhesive and, while this process is not offered as a substitute for welding by regular methods now in use, this form of welding can be used most effectively in many applications which heretofore presented a problem in the joining of metals by other than mechanical methods.

Colalloy atomic welding is especially recommended for light gage metal joining, for it does a satisfactory job in most cases, without the drawbacks of hard-to-handle and costly welding apparatus and operation, and with none of its drawbacks such as possibilities of warping, burning, light gage limitations and time factors. "Colaweld" can also atomically weld most other metals, both ferrous and non-ferrous. More information on specific problems is available from the Colonial Alloys Co., Colonial Philadelphia Building, Philadelphia.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

A Digest of
Important Developments
in the World of Metals

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1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

5. General

Articles pertinent to more than one of the previous sections.

Announcing— THE NEW Metallurgical Engineering Digest

WITH THIS ISSUE WE PRESENT a completely transformed "abstracts" department with a new title, broadened sectionalization and—most important—a modified publishing policy.

The fundamental differences between the old service and the new are accurately indicated in the change in name from "Abstracts" to "Digest." The old department was a collection of necessarily short, uninterpreted *abstracts;* the new "Metallurgical Engineering Digest" will have longer and much more informative *digests* of the most important articles published throughout the world, designed to provide directly-useful information to busy engineers, executives and operating men who lack the time or facilities for studying original articles, particularly in foreign publications. Metallurgical engineering will be featured rather than the science of metals, and the "straight" reporting of the usual abstracts service will be replaced by editorial interpretation and correlation wherever possible. When feasible, "composite digests" reviewing two or more recent articles on a given subject under one heading, for purposes of correlation or editorial comment, will be presented.

The modified service will no longer be a complete index of the literature. Over 80 per cent of our readers, however, are operating engineers and executives, who tell us that they overwhelmingly prefer selection to completeness of coverage if the selection can bring them, as the new service is aimed to do, directly-useful condensation of the actual contents of the world's best metallurgical engineering articles. Selection will be based on breadth of interest, importance and reliability of the original articles, the novelty and originality of their contents and their utility to engineers as distinguished from scientists. Selecting and digesting will be done by the same metallurgically-experienced staff as formerly, and, as always, a large part of the material will be referred to "advisory editors" so that readers may be assured of technical accuracy. The scope of the service—that is, the general fields covered—remains the same, except that articles on ore concentration will not henceforth be digested.

The transition from short "abstracts" to longer, more informative digests has been effected gradually during the last year. The gradual change has been accompanied by a notable improvement in timeliness, so that readers may expect from now on to read most of the digests within 3 months after the publication of the original articles. The new sectionalization should be convenient for the reader, as it is based on a logical grouping of articles into major fields—Production; Processing and Fabrication; Properties and Application; and Testing and Control. As before, non-ferrous as well as ferrous problems will receive their full share of attention.

The purpose is to provide the readers each month with a bountiful assortment of directly-useful condensations of the contents of the best metallurgical articles published throughout the world, carefully selected, edited, interpreted and correlated, and presented in readable form. With the emphasis on direct, practical and immediate engineering utility, the digests thus supplement the regular feature articles, which are published on precisely that basis.—The Editors.

1 Production
OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

Straightening Aided by Heat

A New Warm Straightening Machine ("Eine neuartige Warmreckmaschine") E. Opitz. *Metallwirtschaft,* Vol. 18, Sept. 30, 1939, pp. 820-821. Descriptive.

Shapes, rods and tubes produced by rolling, extrusion or drawing are crooked and must be straightened in a subsequent stretching operation. This operation is difficult to carry out on hard and brittle materials which often fracture, resulting in damage to the straightening machine. By applying a low-voltage high-amperage electric current to the piece being straightened while it is in the machine, it is possible to raise its temperature and thus increase the plasticity of the material. The material can now be straightened with less stress.

The heating cycle is so short that this method will not destroy the properties of heat-treated stock even if the annealing temperature is momentarily passed. Twenty-ton machines suitable for sections up to 700 mm.^{2} used in brass and light metal works require 120 kv.-a. for heating power while the 50-ton machines used in the steel industry require 300 kv.-a. for sections 1700 mm.^{2} in cross section. GA (1)

1a. Ferrous

Pouring Cast Iron

Foundry Technique for Cast Iron in Theory and Practice ("Die Giesstechnik für Gusseisen in Theorie und Praxis") J. Petin. *Giesserei,* Vol. 26, Oct. 6, 1939, pp. 497-505. Review.

The flow laws of liquid masses are applied to the casting of iron, with particular attention to the passage of the molten iron from the gates through the mold cavities and into the risers. The determination of the diameter of the gates depends on the casting time "t" and velocity "v" with which the liquid iron flows through the gate. The casting time is a fairly well-known factor; thus, from a 1-ton ladle 26 lbs. of iron per sec. can be poured. The velocity $v = \sqrt{2gH}$ ("g" = acceleration of gravity, "H" = height of fall of liquid) has to be corrected for frictional and eddy losses in flowing through the mold, and for the action of the gases developed. On the basis of experimental results a chart was prepared from which can be taken the amount of iron that can be cast for different sections of the gates when H = 20 or 100 cm.

For small manual casting ladles 1.9-9.5 kg. iron can be poured in 1 sec.; the exact quantity is determined mainly by the kind of ladle and the velocity with which the ladle can be tilted. The gate for a given casting must be made so that the amount of iron that can flow through it per sec., with the kind of pouring used, is the same as the quantity/sec. that can be poured from the ladle. The risers must be so arranged that the pouring factors become the best possible. Application of a properly developed casting technique results in diminished rejects and bad castings, and improves the physical properties of the casting generally. Control of the composition of the cast iron alone will not give perfect results. In general, according to the author, foundrymen employ gates that are much too large.

Perhaps it is obvious that the economy of the casting process, or in other words the succesful operation of a foundry, is increased considerably if rejects and scrap are reduced. The weighted importance of such factors is, however, often surprisingly great. If, for instance, the direct cost of a finished casting is $2.00 per 100 lb., overhead $5.00 per 100 lbs., and scrap value $1.00 per 100 lbs., then the cost for 1 lb. of scrap is (2.00 — 1.00) per 100 = $0.01, and for rejects (5.00 — 1.00) per 100 = $0.04, which proves the importance of savings possible by a proper casting technique. It is recommended that drawings show the arrangement and size of gates and their standardization according to the pouring methods employed in the foundry in question. Ha (1a)

Cupola Combustion Control

"Combustion Control in Cupola Operation." S. C. Massari (Assoc. of Manufacturers of Chilled Car Wheels) *Foundry,* Vol. 67, Oct. 1939, pp. 28-30, 98, 100. Practical review.

Loss of elements, economy of operation and potential quality of the iron melted are functions of the atmosphere existing in the melting zone of the cupola. To achieve the greatest economy and maximum uniformity of iron, the following factors require regulation: (1) Ratio of coke to quantity of iron melted; (2) ratio of air to coke; (3) rate of combustion of coke; (4) temperature of combustion; (5) efficiency of combustion; (6) efficiency of heat transfer to the iron; and (7) losses of Si, Mn, etc. Analyses of the gas within a cupola vary, depending on the time and location from which samples are obtained, but in each case bear a definite relation to the process. If 4 sampling tubes are placed at 90° intervals around the circumference of the cupola about 3 ft. below the normal stock level, a representative average over the entire cupola is obtained. The composition of the effluent gases, together with that of the metal issuing from the cupola spout, afford a means for obtaining the relation between the loss of Si and Mn during the whole process and during the various stages of combustion. The maximum economy is obtained in melting low-Si iron when the CO_2 concentration is between 13 and 14%; in melting high-Si iron, it should be between 11.5 and 12.5%.

Uniformity of combustion is almost entirely dependent upon the type and quantity of coke in the combustion zone, together with the amount of air used. Measuring the amount of air entering and correlating this with the data from the CO_2 recorder gives the combustion relation that actually exists. Automatic control of the blast volume involves the use of differential pressure controller actuated by a pitot tube in the blast main, which measures the relative volume of blast entering the cupola. Carbon dioxide compensating mechanism is part of the CO_2 recording analyzer and is connected to a small reversing motor which is part of the differential pressure controller. Sometimes, even with automatic control, a uniform level of combustion is not obtained. Due either to variations in rate of combustion of coke, or coke size, or other factors, a constant stage of combustion cannot be maintained unless the volume of air entering the cupola is changed to meet these changing conditions. VSP (1a)

Operating a Blast Furnace on Low-grade Ore

Coke Consumption, Material and Heat Balance in a Blast Furnace, Particularly One Using Low-grade Ore ("Koksverbrauch Stoff- und Wärmebilanz von Hochöfen, besonders beim Verhütten armer Erze") Fritz Wesemann. *Arch. Eisenhüttenw.,* Vol. 13, Sept. 1939, pp. 113-122. Original research.

On the basis of extant data calculations are made of the coke consumption, in heating and reduction, of various blast furnace burdens, especially with low-grade ores. The factors involved are very clearly analyzed, and the calculations can be readily applied to making basic Bessemer pig iron, foundry iron, and spiegel. Comparisons are made between working with high- and low-grade ores.

The coke consumption per ton of pig iron when using low-grade German Salzgitter ores containing about 25% Fe is more than twice that when using imported Swedish ore containing 46% Fe. However, when the Salzgitter ore is sintered and concentrated the coke consumption is about the same as with the Swedish ore. When working with the low-grade ore it is possible so to adjust the charge and blast as to give the same coke consumption for the total amount of material passing through the furnace, *i.e.,* ore, coke, slag and air, as when working with high-grade ore. Even under these most favorable conditions, of course, the output of pig iron per ton of coke for the low-grade ore is still less than half that for high-grade ore. SE (1a)

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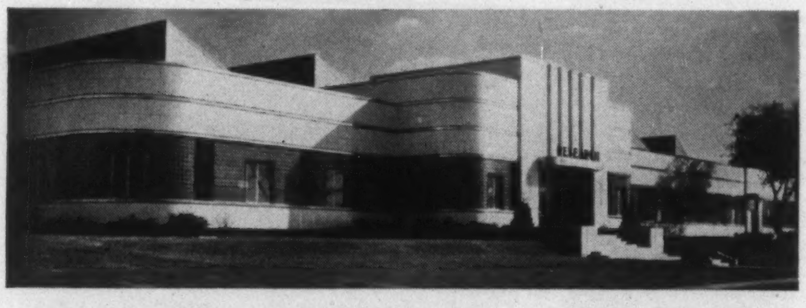

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Steel Ingots

"NINTH REPORT ON THE HETEROGENEITY OF STEEL INGOTS." *Iron Steel Inst., Special Rept.*, No. 27, 1939, 84 pp. Research and review.

In the opening section the paper by Hultgren and Phragmén is reviewed. [This important paper was abstracted in *Metals and Alloys,* Vol. 10, May 1939, p. MA 266 L/7. A full length version in English has recently been published by the A.I.M.E.—Solidification in Rimming Steel Ingots," *Trans. Amer. Inst. Mining Met. Engrs.*, Iron and Steel Div., Vol. 135, 1939, pp. 135-244.] Data on the variation in composition from outside to center of rimmed ingots are given by T. Swinden. The data include analyses for C, Mn, P, S, O and N. O and N were determined by vacuum fusion. Going from surface to center in the rim most of the elements decrease slightly, but the decrease in O is quite large, from 0.04 to 0.015% approximately. At the junction of the rim and core, concentrations rise to a maximum for S and P, and possibly C. For the other elements they rise to a value equal to the average composition of the core. The observed results are discussed in light of the Fe-C-O diagram suggested by Hultgren and Phragmén. The second half of the report is devoted to descriptions of manufacture of rimming steel at different British plants. JLG (1a)

Blast Furnace Slags

"EFFECT OF THE VOLUME AND PROPERTIES OF BOSH AND HEARTH SLAG ON QUALITY OF IRON." G. E. STEUDEL (Carnegie-Illinois Steel Corp.) *Metals Tech.*, Vol. 6; Sept. 1939, 22 pp. Practical.

Slags in the bosh are more basic than slags in the hearth. In normal furnace operation it is necessary to have bosh slags that are fluid at rather low temperatures, and the hearth slags must be basic enough to desulphurize the Fe. Analyses of slags produced at the author's plant—Lake ores—are given. It is shown by means of ternary diagrams giving melting points and viscosities that slags slightly less basic might have more desirable characteristics. Furnaces were run with decreased stone and coke in the burden, and by flushing the slag less often and leaving as much as possible in the furnace after a cast the S was kept under the desired limits. The furnaces have not been operated under the new schedule long enough to be certain that they are being operated more advantageously, but preliminary data indicate that they are running smoother, that less coke per ton of Fe is being used, and that composition is being successfully controlled. JLG (1a)

Gating and Feeding Steel Castings

"GATING AND FEEDING IN STEEL FOUNDRY PRACTICE." B. RAMASESHIAH. *Foundry Trade J.*, Vol. 61, Sept. 28, 1939, pp. 218. Practical.

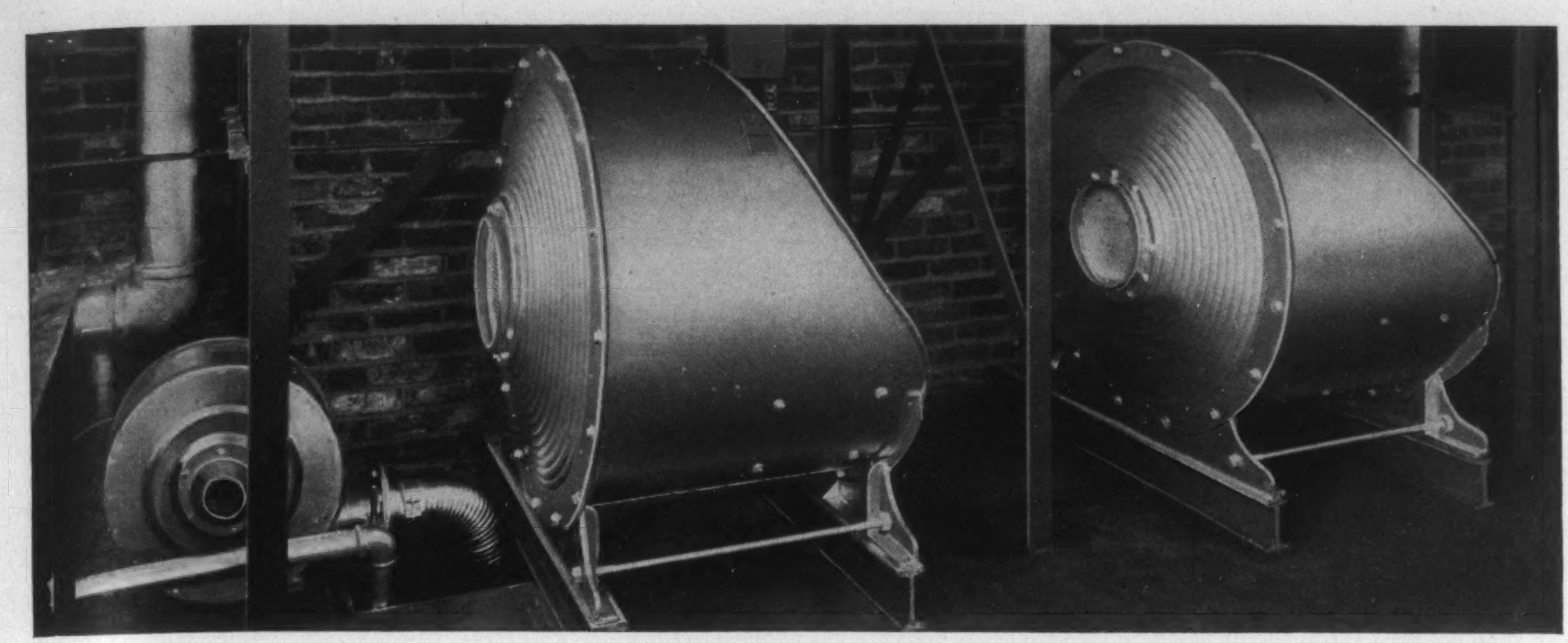
Twenty-three important principles of gating and feeding are given. The following three are of particular interest: (1) Long runner passages connecting two distant points in the casting must not be cut in a straight line, but in a curved or S or zig-zag line to avoid contraction strain on the casting. (2) Whenever there is sufficient space between feeders and bars, and whenever feeders are situated apart at greater distances in a straight line, it is advisable to create collapsible pockets by ramming a block of wood about 3 in. from the feeders in the mold, removing it and filling it with loose sawdust and backing with open sand, before the feeder blocks are taken out for finishing. (3) When running massive casting, fireclay sleeves or burnt firebricks should be chosen for runner passages in preference to sand to avoid sand fusings and washouts. AIK (1a)

Solidification of Steel Ingots

THE PROBLEM OF SOLIDIFICATION OF STEEL INGOTS ("Ein Beitrag zur Frage der Erstarrung von Stahlblöcken") R. HOHAGE & R. SCHÄFER. *Arch. Eisenhüttenw.*, Vol. 13, Sept. 1939, pp. 123-125. Original research.

Medium-C, Cr-Ni steels varying in Cr content from 0.87 to 18.0% and in Ni from 1.0 to 7.0% were cast into 85 mm. diam. water-cooled copper molds. The ingots were sectioned and the type of crystallization observed, *i.e.*, whether the crystals were small and equiaxed or were elongated and radial. The formation of long radial crystals practically to the center of the ingot was called "transcrystallization". Melting in vacuum eliminated transcrystallization, the crystals being small and equiaxed throughout the section of the ingot, but deoxidation with Al up to 0.6 g. Al per kg. of melt did not. Transcrystallization was favored by high pouring temperature.

Transcrystallization was attributed to the presence of hydrogen in the melt. Conditions which favored the absorption of hydrogen, such as high casting temperature, the presence of Ni and Si as alloying elements, and varnished molds, all produced more pronounced transcrystallization. SE (1a)



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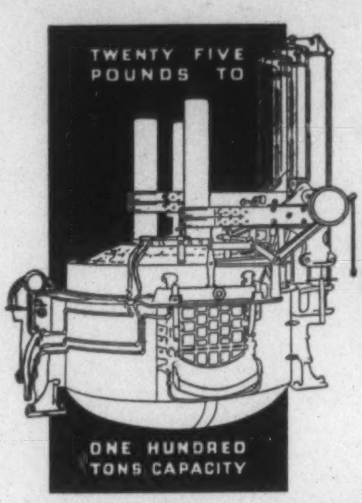

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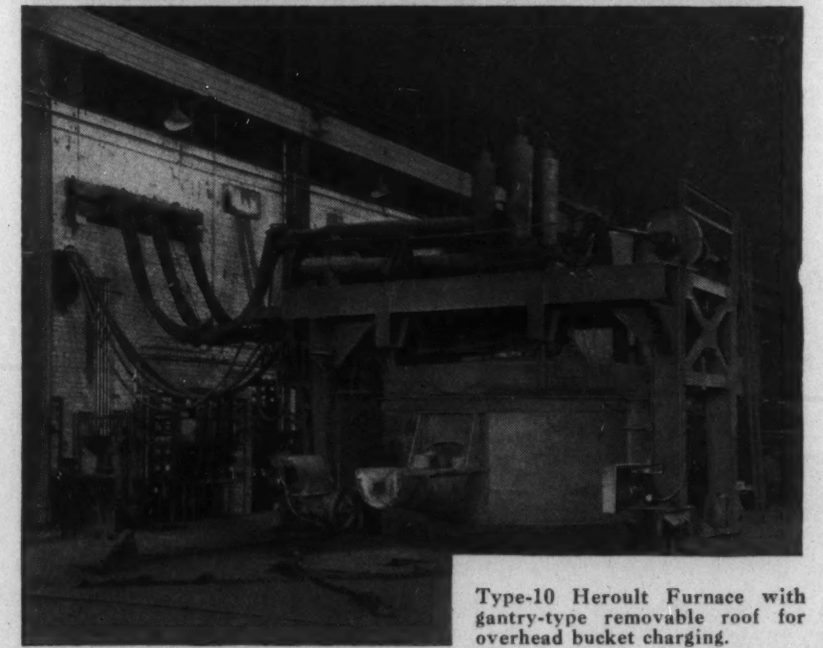

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1b. Non-Ferrous

Gas Evolution on Rolling Light Metals

GAS ABSORPTION OF ALUMINUM AND MAGNESIUM ("Gasaufnahme von Aluminium und Magnesium") H. WINTERHAGER. *Z. Ver. deut. Ing.*, Vol. 83, Aug. 5, 1939, p. 898.

Recent investigations have shown a relationship between the emission of occluded gas and the degree of deformation of aluminum; up to rolling reductions of about 70%, gas is evolved only slightly more than in cast aluminum (1.5 cc. H_2/100 g.), but above these reductions the amount given off increases very rapidly so that at 100% reduction about 18.5 cc. H_2/100 g. of metal are given off. Repeated deforming and remelting produce a metal which gives off no more gas, and can be considered practically gas-free; this occurs after about 150-200 cc. H_2/100 g. aluminum have been removed. The gas once given off is not absorbed again by the metal.

Absorption of gas in aluminum can occur in two different forms: (1) Irreversible binding of gases (H, CO, CO_2), which occurs probably in the electrolytic separation of Al. Gases so held amount to about 200 cc./100 g. of metal and can be removed only by applying extremely high forces. (2) Reversible binding of gases, which represents a true equilibrium depending on temperature and pressure. Gases bound in this way amount to only a few cc./100 g. Blisters in rolling are due to the former type of gas absorption, while coarse pores are caused by the latter.

The conditions for magnesium are similar, but the tie between gas and metals seems to be somewhat less strong than in the case of aluminum. When determining the gas content of Mg by the hot-extraction method, it must be remembered that Mg is sublimed and absorbs gases again in condensing, so that repeated sublimation *in vacuo* is necessary to determine accurately the gas content.
Ha (1b)

"Oxygen-free" Copper

"PROPERTIES AND METHODS OF MANUFACTURE OF OXYGEN-FREE COPPER." P. I. BARANOV. *Tsvetyne Metally,* No. 1, Jan. 1939, pp. 73-83. In Russian. Descriptive.

A description is given of results of experiments made with the purpose of developing a process of manufacturing oxygen-free Cu with the use of Li and Be and by melting under CO_2 atmosphere. Wire bars 5.5 x 5.5 x 55 cm. cast from cathode Cu melted under charcoal and deoxidized with 0.012% Li or Be have high density, good mechanical properties and workability. Two-mm. wire drawn from these bars has electrical conductivity not lower than that of OFHC Cu, but lower ductility.

Bars cast from cathode Cu under charcoal without addition of Be or Li are porous and low in mechanical properties. Wire made from these, however, has satisfactory conductivity and ductility. Cathode Cu melted in a CO_2 atmosphere and cast into vertical molds possesses good mechanical properties and density; wire made from these bars also possesses good mechanical properties and good conductivity. Copper melted in a hydrogen atmosphere is lower in conductivity and mechanical properties, particularly when in the form of cold drawn or annealed wire. 15 references.
BND (1b)

Die Casting Practice

A Composite

Modern engineering practice in the specification of die castings and the selection of metals to be cast usually involves close collaboration between the product designer and the metallurgical engineer familiar with melting factors, casting behavior, and wear and tear on the dies and other equipment. The extent to which engineering design for die castings must depend on the metallurgical operation of making the casting is indicated in 3 recent articles on general practice, on the manufacture of Mg alloy die castings and on the durability of equipment for die casting Zn alloys.

Die design and materials are discussed by A. G. THOMSON ("Pressure Die Casting", *Foundry Trade J.*, Vol. 61, Oct. 12, 1939, pp. 258-259). Under the influence of the high pressures employed in die casting, the flow of metal through the gate is very rapid. Consequently, the position of the gate must be such that an even flow of metal to all portions of the die is obtained without unnecessary change of direction, since such a change would be likely to entrap air. The main provision for venting is usually made on the parting line of the die. However, on many castings, venting at the parting line of the die alone is not sufficient. When copper is to be cast, owing to the higher temperatures involved, the die halves must be of one-piece construction. The majority of castings require the use of one or more cores in order to form the cavities and other irregularities.

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to control as far as possible the temperature of the die. Naturally, this becomes more important in the case of the high-melting point Al- and Cu-base alloys. All dies should be heated prior to use, as otherwise flow lines will appear on the surfaces of the first casting produced. In the design of dies provision must be made for the contraction in cooling after the casting has been ejected from the die. With Pb- and Sn-base alloys the allowance may vary from 0.001 to 0.002 in./linear in., while in the case of Al alloys it may be as high as 0.008 in. per in.

The material employed for the dies plays a vital part in the success of die-casting operations. For copper alloys it is customary to employ high-grade alloy steels for the dies. Where parts are required in only moderate quantities and the casting pressure is not unduly high, a Cr-V steel will give good results. Where longer die life is required or the nature of the parts calls for greater casting pressures, steels containing W and Cr should be employed. Dressing is usually necessary in the case of dies for Cu-base castings and it is also frequently employed on Al casting dies. The dressing takes the form of an insulating solution, which is sprayed on the die surfaces. Its use, however, should be avoided where possible because it delays and complicates the casting operation. The finish of a casting is usually better if dressing is not employed, provided the die impression has a good surface.

Some of the operating factors particularly important in Mg alloy die casting are discussed by HERBERT CHASE ("Technique and Equipment for Die Casting Magnesium Alloys," *Light Metals*. Vol. 2, Nov. 1939, pp. 375-377). The successful application of Mg alloys to the die casting process depends upon the use of even higher casting pressures than those possible in the "gooseneck" machines that utilize high pressure air as a means of injecting metal into the die. An inert atmosphere in the machine, as well as over the metal in the holding pot is necessary to prevent excessive oxidation during holding and casting. The cold chamber type of die casting machine which had been used for brass die castings was found suitable for magnesium die castings. Pressures as high as 6,000 lbs./in.^{2} have been tried in this work, but according to the experience of the Dow Chemical Co., there is no advantage in die casting at pressures in excess of 4,000 lbs./in.^{2} However, it is possible in certain cases that the design of the die as well as the temperature of the metal may require higher casting pressures for best results.

In the Reed-Prentice die casting machines, the injection cylinder and plunger are made of Nitralloy for abrasion resistance. The dies themselves are made of tool steel of various compositions. Plain carbon steel may be used if only a relatively short die life is required, but dies made from a 5% Cr, 5% W steel have been found more satisfactory. Small machines may be capable of 6 shots/min., while larger machines may operate at about 100 cycles/hr. A nitrogen atmosphere is customarily used to prevent oxidation of the magnesium after it is introduced into the die casting machine. The metal in the holding pot is similarly protected by a SO_2 atmosphere. A flux is often added to the metal to assist in coagulating dirt or dross. The sludge thus accumulated is removed from the bottom by a perforated skimmer.

Transfer of the molten metal from the pot to the machine is accomplished so rapidly that the oxidation occurring is negligible. The usual casting temperature ranges from 1175° to 1200° F. Venting that is suitable for Al alloys is not necessarily suitable for Mg alloys; careful attention must be paid to this detail. Average die temperature may be taken as 350° F., although it may vary from 250° to 500° F. Water cooling of the die may be necessary in certain cases, but it is not normal practice. Overall metal recovery is said to be about 90% for large to medium size castings, but is somewhat less for smaller castings.

Zinc-base die castings are still the most widely applied of all, and problems associated with their manufacture have therefore great economic importance. The suitability of different ferrous materials for plungers and dies used in die casting Zn alloys was studied by E. A. ANDERSON, G. EDMUNDS & C. W. SILLER ("A Study of the Action of Molten Zinc Alloys on Pressure Die Casting Equipment," *Metals Tech.*, Vol. 6, Sept., 1939, 14 pp.) In the pressure die-casting of Zn alloys it is customary to force the molten alloy into the die by means of a plunger moving in a bushing with a clearance on the diameter of the order of 0.002 in. With small amounts of Al in the alloy, successful operation is possible because alloying between the plunger or bushing and the Zn is not too rapid. In order to determine the suitability of different metals for plungers and dies, a laboratory machine was built in which a plunger operated in a bushing with the assembly immersed in molten Zn or Zn alloys. The clearance was 0.005 in. and the time required for binding when operated every 30 sec. was determined. The materials investigated included cast iron, Ni cast iron, stainless steel, nitrided cast iron, and wrought iron. The wrought iron was the least resistant and the nitrided iron the most resistant. Stainless steel was better than cast iron. Nickel cast iron seemed to be slightly worse than plain cast iron. Microstructures of the attacked materials are shown. Zinc showed some tendency toward preferential attack of the cast iron along graphite flakes. X (1b)

2 Processing and Fabrication

FORGING, FORMING, MACHINING HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

Electrolytic Polishing

A Composite

Originally developed by Jacquet as a laboratory method of preparing samples for metallographic examination, electrolytic polishing bids fair to become important as an industrial method of finishing metals.

A description of the method and a review of its applications are given by P. A. JACQUET ("Le Polissage Electrolytique des Metaux et ses Applications", *Tech. Moderne,* Vol. 31, Aug. 15, 1939, pp. 561-569). It has been found that most metals can be polished electrolytically by anodic attack under carefully controlled conditions, because of the selective attack of the protruding irregularities. The finish is very brilliant for homogeneous metals. The metal is generally rough-finished on emery paper, washed in alcohol, dried, then electrolytically polished. The potential drop between cathode and anode must be accurately regulated. Polishing conditions for common metals and alloys are given below (anode about 1.5-2 cm. removed from cathode):

Metal	*Electrolyte*	*Current Density amps./dm..^{2}*
Copper	Commercial orthophosphoric acid, sp. g. 1.71	9-10
Brass (single phase)	Commercial orthophosphoric acid, 430 g./1.	9-10
Brass (double phase)	Commercial orthophosphoric acid. 530 g./1.	9-10
Cobalt	Commercial orthophosphoric acid, sp. g. 1.35	9-10
Zinc	Commercial orthophosphoric acid, 25% water solution	16
Aluminum or its alloys	Perchloric acid (1.480 sp. g.) plus pure glacial acetic acid	5-9
Tin or Lead	194 cc. perchloric acid (sp. g. 1.6) plus 805 cc. glacial acetic acid	10
Iron or Low-alloy Steel	185 cc. perchloric acid (sp. g. 1.6) 765 cc. glacial acetic acid 10 cc. water	4-6
Special Steels	335 cc. perchloric acid (sp. g. 1.6) 665 cc. glacial acetic acid	6-7
Nickel	210 cc. perchloric aid (55° Be) 790 cc. glacial acetic acid	50

In the case of alloys with an adherent oxide film, such as 18-8, all traces of the film must be removed by abrasion before polishing. The technique is also splendid for micrographic work, especially for low-melting-point alloys and specimens with many inclusions. All details of the true structure are revealed without the distortion associated with the cold work of mechanical polishing. Large-size specimens may be polished in the same time required for small specimens (generally about 10-20 min.). Other useful applications in the laboratory include determination of true optical properties, effect of thin cold worked layers on tarnishing, etc. The method is commercially applied for finishing nickel nuts in radio tubes, mirrors and reflectors (electrolytically polished surfaces tarnish less readily than surfaces polished in usual manner), as well as for polishing very small or complicated pieces.

An independent study of Jacquet's method has been made by W. C. ELMORE of Swarthmore College ("Electrolytic Polishing," *J. Applied Physics,* Vol. 10, Oct. 1939, pp. 724-727). Investigation by means of voltage-current curves of the electrolytic polishing of copper indicates that the rate of solution of copper at the anode is controlled primarily by its concentration gradient in the electrolyte adjacent to the anode. Because there is greater diffusion from raised areas of the anode by virtue of the steeper concentration gradients, these are continuously being leveled off. Details for polishing pure iron and silicon iron by this method are given together with a description of a convenient type of electrolytic cell for such work. Iron specimens thus polished are brighter than those polished mechanically. X (2)

Electrolytic Cleaning

ELECTROLYTIC DEGREASING WITH SIMULTANEOUS FORMATION OF A METALLIC COPPER COATING ("Cuprodekapierung, elektrolytische Entfettung bei gleichzeitiger Bildung eines Metallüberzuges") V. P. SACCHI. *Korrosion u. Metallschutz,* Vol. 15, Oct. 1939, pp. 321-339. Survey.

The subject of methods of preparing metals for electroplating is extremely broad, and constantly expanding. The term "degreasing" *(Entfettung)* as used in this article means not only freeing the material of grease and oil, but of any kind of surface dirt introduced in the operations prior to electroplating. Mechanical, physical, chemical and electrochemical methods are in use, usually several of them in conjunction with electrolytic degreasing, ordinarily the final step in obtaining a properly cleaned surface. Electrolytic degreasing combined with the deposition of a metal layer is a comparatively recent development.

A particular advantage of electrolytic degreasing with simultaneous metal deposition is that the solutions used can be applied cold and can be employed for several years, so that in spite of their initially high price, they are actually quite economical. Also, such solutions have a better throwing power, probably because of the simultaneous deposition of Cu. In addition, solutions of the simultaneous-deposition type permit easier control of the degreasing operation. This, however, does not mean (contrary to the generally held view) that the appearance of the Cu layer is a sure indication of perfect degreasing, for such a tell-tale can only be employed with perfect balance of Cu and cyanide in the solution; excess of cyanide prevents or interferes with Cu deposition and adhesion, while excess of carbonate causes oxidation of the degreased surface; insufficient carbonate and cyanide results in the deposition of Cu on the imperfectly degreased surface, with consequently poor adhesion. The slight Cu film delays passivation of the metallic iron or steel surface during transport from the degreasing bath to the final regular plating bath. The deposition of a brass or Cd layer instead of a Cu layer is not so desirable, for the baths are more costly and difficult to control.

The new method can be applied to iron, steel, cast iron, brass, copper, bronzes of all kinds, zinc, Pb-Sn alloys and white-metals generally, but is not suitable for parts that are subsequently to be plated with Cd or Zn, for Ni-plated articles or parts to be stored for subsequent Cr plating, for Al and Al alloys, and, of course, for degreasing parts the surface of which must subsequently be machined. The degreasing-Cu plating process will achieve a double purpose, a chemically and physically pure and clean surface and a Cu-coated surface of absolutely uniform crystal structure. In practice the following stages are involved: (1) A cleaning bath that loosens the dirt. (2) Saponification of the oil and grease esters by alkalies; caustic soda is preferred to potash for economical reasons, although the soda soaps formed are harder. (3) Emulsification. The non-saponifiable materials are removed through the formation of a suspension of them in the liquid. (4) Peptization, *i.e.* the transformation of the non-saponifiable substances into colloidal particles to give a suspension in a solid medium, instead of in a liquid as in the emulsion.

The actual degreasing and Cu-plating stages are similarly classified as: (5) Mechanical degreasing. The hydrogen developed at the cathode exerts a strong mechanical effect; more than 600 cc. H are freed by 100 amp./min., which acts almost like compressed air on the particles adhering to the surface. As this hydrogen is in "nascent form" it exerts, besides the mechanical effect, a strongly reducing action which removes any trace of passivity from oxidation by air or solution. However, as the hydrogen is also slightly adsorbed by the metal, the latter's strength may be reduced, and may not be capable of complete restoration. (6) Degreasing by electric current. The emulsified and peptized dirt particles are ionized and repelled (by absorbing electrons) from the cathode and transported to the anode (by electrophoresis). There are, however, also particles that absorb positive ions and are retained at the cathode; their behavior is not yet fully clear, and it may be that their effect is nil in an alkaline medium. (7) Formation of the Cu coating. The degreasing-Cu plating baths always contain the metal as a complex salt which in the bath is decomposed, and the deposit is formed by a primary electrochemical reaction rather than, as formerly assumed, by a secondary reaction. The deposit appears after 15 sec., and reveals no imperfections under the microscope even at 2500 magnifications. These various stages are discussed at length with respect to composition, stability of bath used, and temperature.

Formulas for suitable baths and operating conditions are given. For soft metals, like Sn, Pb and Zn die castings, a bath containing 50.0 g./l. NaOH, 50.0 g./l. Na_2CO_3, 50.0 g./l. sodium cyanide, 12.5 g./l. copper cyanide and 6.5 g./l. sodium silicate is employed; for iron and steel: 15 g./l. NaOH, 30 g./l. potassium cyanide and 0.1 g./l. metal (Cn). Several other modifications given are not recommended. A fully effective solution has a yellow-green color; pronounced yellow color and a vividly red anode point to excess of cyanide, while a decidedly green solution indicates lack of cyanide. Anodes of Ni or Ni-plated iron are preferable. Carbon anodes should not be used, and Cu anodes are not recommended either. The cathodic current density should be 8-15 amp./dm.^{2}, which produces the Cu deposit after 15-20 sec.; the total degreasing Cu-plating process should be finished in 60-90 sec. Directions for filtering the solutions, suspending the articles in the bath, and selection and treatment of anodes are given in detail. 16 references. Ha (2)

2a. Ferrous

Constant-temperature Studies of Heat Treatment

"ISOTHERMAL TRANSFORMATION IN STEELS." E. S. DAVENPORT (U. S. Steel Corp.) *Metal Progress*, Vol. 36, Nov. 1939, pp. 623-629. Extracts from the 1939 Campbell Memorial Lecture of the A. S. M.

The so-called "S-curve" (see *Metals and Alloys*, Vol. 8, Jan. 1937, p. 22), which depicts the time required for the breakdown of austenite to ferrite and carbide at any constant temperature below the critical, has opened up in the last few years new avenues of information on the heat treatment of steels. Ten years of experience with isothermal transformation have shown that investigations of this type have (1) provided a new and clearer picture of austenite transformation, with a new basis for a broad general philosophy of heat treatment, (2) demonstrated the outstanding influence of the actual temperature of transformation on the character and properties of the several structures possible in a given steel, (3) permitted the evaluation of the effect of alloying elements on structure, properties, hardenability, etc., and (4) contributed to a rational explanation of the influence of coarser austenite grain size, which displaces the S-curve in the same manner as do alloying elements.

Attention is called to 2 characteristic features of the S-curve: (a) The 2 temperature regions of *rapid* transformation—one in the 900°-1100° F. range (the Ar_1 region), the other below 200° F.; (b) the 2 temperature regions of *slow* transformations—one just below the Ae_1 temperature, the other in the 300°-800° F. range. Constant-temperature studies reveal that many steels fail to show, within the rapid-transformation range of 800°-1100° F., the regular increase in hardness that might be expected from the decrease in transformation temperature as compared with the product of transformation at somewhat higher temperatures. Within this 800°-1100° F. range the microstructure changes from lamellar or nodular to acicular, suggesting a fundamental change in the mode of transformation in this temperature range.

Investigations of the mechanical properties of the acicular structure (bainite) resulting from constant temperature treatment in the 400°-800° F. (lower slow transformation range) have shown this structure to possess an unusual degree of toughness and ductility at high hardness levels (Rockwell C -50 to 60). The commercial method of constant-temperature heat treatment known as "Austempering" (see *Metals and Alloys*, Vol. 10, Aug. 1939, pp. 228-242) is based on the development of this structure in the steel being treated.

Studies were made of the influence of individual alloying elements—C, Mn, Ni, Cr, Mo, V and Co—on the location and shape of the S-curve, particularly in the vicinity of the Ar_1 range, which is the most significant part of the curve in ordinary heat treating. The transformation at lower temperature levels is markedly and consistently retarded by increasing C content; however, in the higher (Ar_1) range the hyper-eutectoid (1.13% C) steel studied was the fastest of the series in starting its transformation. The low-C member of the series (0.54% C) begins to transform quite rapidly in the intermediate range (400°-700° F.) where the higher C steels behave sluggishly. Addition of Cr to lower-C steels retards the transformation in the Ar_1 range, but imparts a characteristic form to the upper part of the curve—a rightward-extending hump—which increases in intensity with rising Cr content. Whatever the alloying element, its effect on the lower portion of the S-curve is subordinate to that of carbon.

The S-curves showing the influence of alloying elements present together in some typical commercial S.A.E. alloy steels of the 0.35-0.45% C grade are strange-looking as compared to the familiar S-curve for eutectoid carbon steel. In varying degree they show pronounced humps in the upper part of the curve, corresponding to a marked delay, within a narrow temperature range, in the beginning of transformation to lamellar products and a greatly extended time for completion of transformation. The humps coincided with the temperature range in which appeared a new microstructure (called simply "X"); Rockwell "C" hardness tests show an irregularity in the sequence of hardnesses through the 900°-1100° F. range (much as with C steels), and the irregularity occurred in the same general temperature range as the anomalous S-curve humps.

In most of the S.A.E. steels studied, the intermediate temperature range yields structures that do not fit readily into the present scheme of metallographic nomenclature; moreover, there are differences in the structure of the different steels at the same temperature level, and it is in the intermediate temperature range that these differences are most pronounced. The structures at different temperature levels in S.A.E. 4140 (0.80-1.1% Cr, 0.15-0.25% Mo) when the steel is about half transformed, are discussed as representative of most of the S.A.E. steels in the same stage. As the temperature decreases from 1350° to 1000° F. the ferrite decreases gradually in volume and the pearlite becomes increasingly finer, until near 1000° F. the pearlite is practically unresolvable or even slightly acicular. At 1000° this rapid-etching product is quite acicular, and there is an unexpected increase in the volume of "pro-eutectoid ferrite," having an acicular or Widmanstätten distribution. In steels rich in carbide-formers this acicular ferrite (the "X" constituent) becomes speckled as though something were precipitating in it as the time at temperature is extended. Thus, the constituent may not be "pro-eutectoid ferrite" but some form of high-temperature acicular product (bainite) reluctant to precipitate its carbon. These structural effects, again, occur at the same temperature levels as the previously-noted humps.

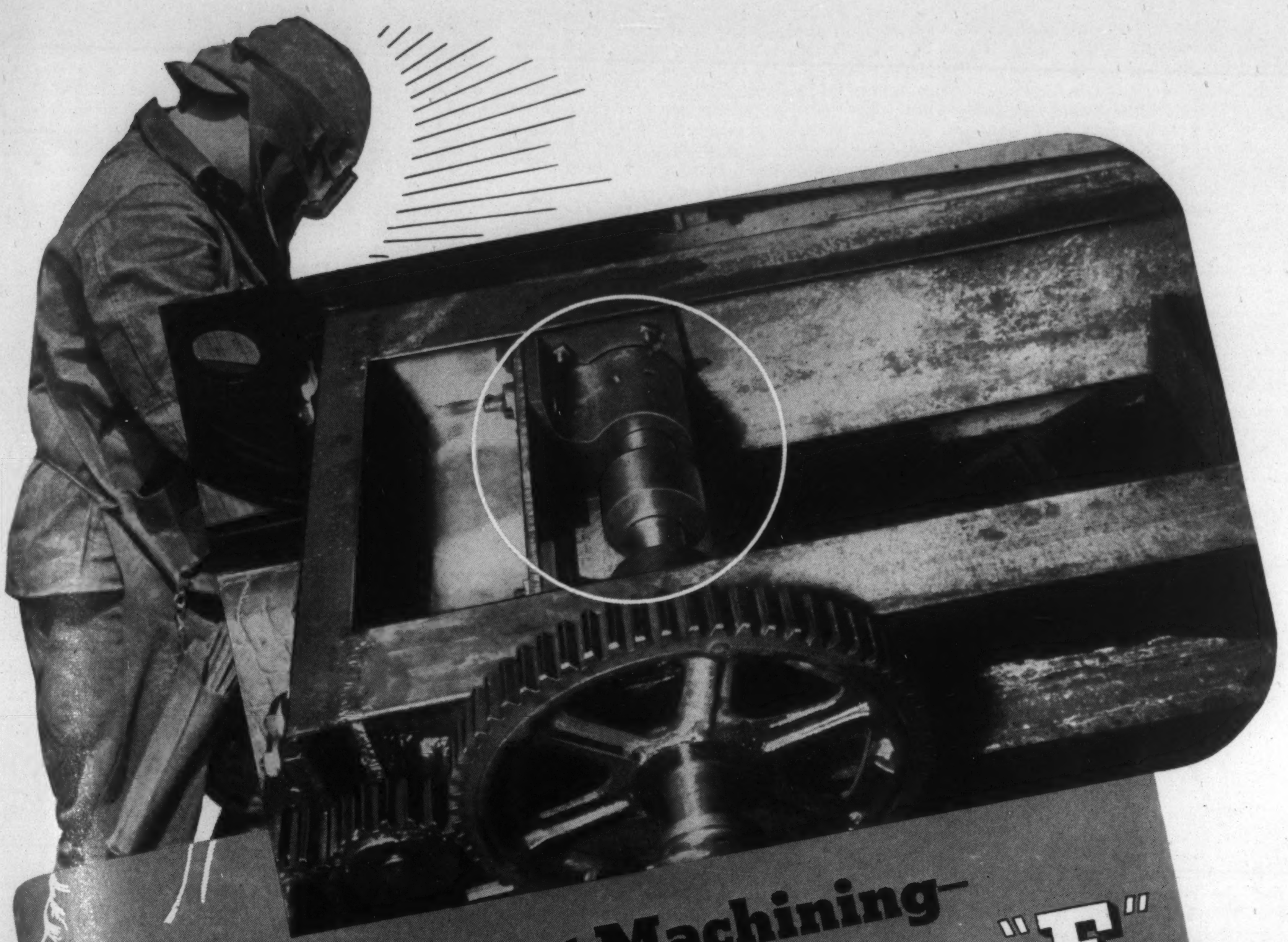
At 900° F. and lower the "X" constitutent disappears and the transformation product becomes more rapid-etching and more acicular, resembling the now-familiar constant temperature transformation product in C steels in this range. The peculiar structural and transformation-rate phenomena occurring in the 900°-1100° F. range are believed to be a manifestation of a fundamental behavior common to both C and alloy steels. The tentative conclusion is offered that the transformation in this temperature range proceeds in 2 distinct stages: First, the separation of the "X" constituent, which presently undergoes some sort of internal precipitation; then the remainder of the transformation proceeds by the acicular process to give a product similar to the bainite of C steels. FPP (2a)

Weld Hardening of Various Steels

"WELD HARDENING OF CARBON AND OF ALLOY STEELS." H. J. FRENCH & T. N. ARMSTRONG. *Welding J., N. Y.*, Vol. 18, Oct. 1939, Supplement pp. 339-347. Review plus original research.

Excessively rapid cooling or too-high-hardenability of welded steels results in excessively hard welds with reduced ductility. The effect of the composition on the maximum hardness obtained in single bead welds on plates was investigated first for plain carbon steels in the range 0.10-0.50% C. The tests were made with a heavily-coated, 3/16 in. diam. electrode at 4 to 6 in. per min. on a steel plate ½ x 6 x 9 in. The bead, 6 in. wide, was laid 3 in. from the ends of the plate on the center line, and the plate was cross-sectioned for hardness tests at 1 in. distance from the start of the weld. Curves are drawn to show the effect of C on weld hardening. There is no marked increase in hardening with C content between 0.10 and 0.25% but from 0.25% to 0.50% there is a rapid increase. The use of preheat is more effective in reducing the hardness in the higher C contents than for the lower-C steels, but for a preheat of 250° F. the hardness remained above 300 Brinell for the 0.40-0.50% C steels and at 600° F. the 0.50% C steel reached 300 Brinell.

A series of alloy steels were tested in the same manner and curves plotted to show the effect of increasing Mo, Mn, Cr and Ni (for various C contents) on the maximum weld hardness as compared with the plain C steels. The slopes of the curves plotted to the same scale of hardness-*vs.*-% alloy decrease in the above order with the slope of the hardness-*vs.*-C being steeper than the others. On the basis of any allowable maximum weld



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hardening the authors consider the tolerance of the ternary alloys for carbon to increase in the order Mo to Ni.

The effect of increase in welding speed (arc travel) and plate thickness on weld hardening of 2% Ni steels was determined experimentally and the results plotted. In the 0.22%, 0.33% and 0.45% C steels (2% Ni), an increase of speed from about 4 to 12 in./min. caused the hardness of each steel to increase respectively from 210 to 300, from 325 to 520, and from 470 to 610 Brinell. An increase in plate thickness from ½ to 1½ in. increased the hardness of a 0.22% C steel (2% Ni) about the same as an increase in C from 0.20 to 0.40% in ½ in. plate.

The effects of precooling the plates before welding was determined by cooling the plates to 10° F. The results are plotted on the basis of hardness *vs.* C content for the precooled plates, and compared with tests at room temperature on the same series of alloy steels. The curves plotted from these results indicate the desirability of keeping the C content at a low level in order to obtain low susceptibility to weld hardening when the steel has been exposed to winter temperatures. The use of preheat to reduce the maximum hardness was investigated for a series of cast and wrought alloy steels containing Mn, Ni, Cr, or Mo, and the results tabulated. Other tests of stress-relieving treatment at 1100° F. after welding without preheat indicate that lower weld hardness is obtained by this treatment than by welding with preheat of 600°-900° F. The authors state that the use of preheat may entail other problems when plain C steels are welded in that grain growth may be stimulated in portions of the joint. Also, if the parent metal has been strained previously the preheat may promote recrystallization or aging effects, and these may produce a brittle structure. At equal or higher yield points the alloy steels of low C content show lower weld hardening than the plain C steels. WB (2a)

Furnace Brazing 12% Chromium Steel

"Properties of Brazed 12% Chrome Steel." F. C. Kelley (Gen. Elec. Co.) *Iron Age*, Vol. 144, Nov. 2, 1939, pp. 33-35; Nov. 9, 1939, pp. 34-35. Research report.

The brazing of Cr steel (with resultant tensile strength of 140,000 lb./in.^{2}) and the results of impact, shear and fatigue tests are described. Pure dry hydrogen is the best atmosphere for this work, as it is capable of reducing Cr_2O_3 at brazing temperature and requires no flux. The steel used in this investigation had the composition: 0.09% C, 12.0% Cr, 0.50% Mn, 0.35% Ni, 0.30% Si, 0.02% P, 0.015% S and balance Fe. Hot rolled bar stock ⅞ in.^{2} was cut into 1-in. lengths, and the sides were ground to remove oxides. The furnace was operated at 2300° F. and the charge was brought up to 2200° F. and withdrawn into the cooling chamber; the heating time was about 20 min. Two samples were brazed and 2 "trial runs" were made to get an idea of the best brazing material to use. Duplicate samples were used of pure Cu, 85% Cu-10 Ni-5 Fe, and 97% Cu-3% Co as brazing material.

Tensile strength results on a single specimen of 33,000 lbs./in.^{2} might be expected in a poorly brazed sample, but the value 139,600 lbs./in.^{2} obtained with the Cu-Ni-Fe alloy-brazed sample was almost unbelievable. Another test was conducted and gave identical results. Microscopic examination showed some diffusion of the brazing alloy into the steel, with the greatest penetration along the grain boundaries. Broken specimens showed that the break occurred at the boundary between the steel solid solution and the brazing alloy. Samples of material heated to 1750° F. and air-cooled after brazing had tensile strength of 11,400 lbs./in.^{2}; 76,000 lbs./in.^{2} elastic limit; 22.5% elongation; and 66.4% reduction in area. On the other hand, a brazed specimen, put directly in the cooling chamber, when tested gave 139,900 lbs./in.^{2} tensile, 0% elongation, and 0% reduction in area.

Impact test specimens with key-hole notches at the joint were machined stainless steel brazed with the Cu-Ni-Fe alloy. Some were tested in the as-brazed condition and some were heat treated at 1750° F. after brazing. The average impact value of heat-treated samples is much higher than those tested in the as-brazed condition. To determine the effect of shape of joints on tensile properties where combination of forces of shear and tension appear, tensile specimens were machined so that there was a male and female part. In this case Cu, Cu-Ni-Fe and Co-Cu were used as brazing materials. The results showed tensile strength of 36,400-43,500 lbs./in.^{2} for Cu-Ni-Fe, and 40,020-40,070 lbs./in.^{2} for Cu. Flat samples 2 x 1 x ⅜ in. brazed with Cu, Cu-Ni-Fe and Co-Cu required 31,000 lbs./in.^{2} to rupture them.

The results of physical tests other than tensile on 12%-Cr steel brazed with 85 Cu-10 Ni-5 Fe were rather disappointing when compared with those for tensile properties. It seemed that the secret of high strength was in the brazing alloy or in a change in composition due to the alloying action of the brazing material and the steel. To test this latter theory 1⅛-in. diam. rods of the Cu-Ni-Fe brazing alloy, and also rods of the brazing alloy to which varying amounts of 12% Cr steel had been added in melting, were cast. Tensile tests of this series (after aging at 900° F. for 5 hrs.) gave values from 56,000 to 60,000 lbs./in.^{2} with "added steel" in the alloy ranging from 2 to 30%. Clearly, the brazing material by such "alloying" could not be made to develop any such high strengths as had been found in the brazed 12% Cr steel.

The high tensile properties of the brazed steel are therefore believed to depend to a greater extent on the physical state of the steel than on the properties of the brazing alloy with the joint thicknesses (0.0008 in.) used in this work. VSP (2a)

Welding Copper Steels

"Welding Copper Steels—A Review of the Literature to July 1, 1937." W. Spraragen & G. E. Claussen (Welding Res. Comm.) *Welding J., N. Y.*, Vol. 18, Sept. 1939, Supplement pp. 289-301. Correlated abstract.

Steels with up to 3% Cu have been successfully fusion-welded without defects. With 4% Cu the weld metal cracks in the direction of welding as if it were intensely hot-short. Welding rods for steel often carry Cu, and Cu-plated rods are commonly used for oxyacetylene welding. Iron containing 7% Cu, or 1 to 3% Cu with 0.5 to 1% Al, or 3% Cu with 0.5% Si has been successfully welded. Resistance butt welding of Cu steels is satisfactory up to at least 2% Cu. On the other hand, the ductility and strength of arc and oxyacetylene welds are satisfactory only up to 0.75% Cu (0.10% C) beyond which both properties decrease rapidly as compared with the unwelded base metal. The recovery of Cu from covered electrodes is practically 100%.

Copper and its alloys may be welded to steel, may be deposited as a surface layer on steel, or may be used as the bonding material to join steel parts. Copper rail bonds are sometimes welded to the rail. In arc welding copper to steel, a flux-covered wire containing deoxidizers is used. In gas welding, a little tin and some Ag or P are used as deoxidizers. In carbon-arc welding, Cu to steel, phosphor bronze is used as the filler metal. Copper has been flash-welded to iron. Copper brazing utilizes Cu to maintain a clean steel surface and depends on (1) alloying of Cu with steel, (2) alloying of steel with Cu, (3) penetration of Cu along grain boundaries, (4) growth of iron grains across the joint. The atomic-hydrogen process can be used to deposit Cu on low-C steel, Invar, and 26%-Cr iron.

Copper-chromium structural steels in the lower strength grades (80,000 lb./in.^{2}) may be welded by metal-arc, oxyacetylene and resistance processes without fear of air hardening. In higher strength grades the weld must be subsequently heat-treated to develop full ductility. Izod impact values in arc-welded Al-treated steel ½ in. thick containing 0.12% C, 0.50% Cu, and 0.75% Cr were 70 ft.-lbs. at room temperature, and slightly higher at 78° C. Strength and ductility practically the same as the base metal have been obtained in Cu-Cr steels (0.11% C, 0.50% Si, 1.02% Mn, 0.70% Cu, 0.35% Cr) without annealing, but with a C content of 0.18% the ductility dropped rapidly. Oxyacetylene butt welds made with Si-Mn, low-alloy steel rod in steel 0.47 in. thick containing 0.17% C, 0.45% Si, 0.87% Mn, 0.49% Cu, 0.17% Cr had tensile strengths equal to that of the base metal, but impact values only about one half as high.

Shielded-arc welds made with Cu-Ni steel electrodes of the same composition as the base metal (which contained 0.10% C max., 0.50% Mn max., 0.30% Si max., 2.00% Ni max., 1.00% Cu max.) had the same strength as the base metal. Machined specimens, ¾ x 1⅞ in., of butt welds in a steel 2¼ in. thick, containing 0.17% C, 0.74% Mn, 2.00% Ni, 1.00% Cu, had about the same yield strength as, but lower tensile strength than, the base metal. The mechanical properties of U butt welds in steels containing 2% Ni and 1% Cu, ½ in. thick, made with 5/32 and 3/16 in. flux-coated electrodes of the same analysis as the base metal were the same as base metal insofar as ductility and tensile strength were concerned. No cracks appeared in the lower-C welds but the higher-C welds in the heat-treated condition developed cracks 3/16 in. long. In welding Cu-Ni steels, the current should be low (⅛ in. electrodes, 80-100 amps.; ¼ in. electrodes, 200-250 amps.) and the arc as short as possible. Layers should be not over ⅛ in. thick and should be of the same width as the groove. The tacking and bottom layer should be chipped out subsequently. Peening is unnecessary, but stress annealing (1½ hr. per in. at 650° C., furnace-cooled is advisable. Welds in the higher-C (0.20% C) grade should be preheated to 100°-150° C. to secure ductility equal to that of the base metal. Oxyacetylene welds in a very low-C steel containing 0.04% C, 0.36% Mn, 0.01% Si, 1.76% Ni, 0.91% Cu had good tensile properties.

Some work on Cu-Mo steels was reviewed. Butt welds were made in a steel containing 0.29% C, 0.74% Mn, 0.24% Si, 0.35% Cu, 0.22% Mo and 0.03% P, with an organic and mineral covered electrode (0.13% C in core rod, 0.5% Mo in deposit). Aside from 10% lower tensile-impact value and ductility, the welds had the same properties as the base metal. Stress relief at 600° C. had a good effect on tensile impact value. Butt welds

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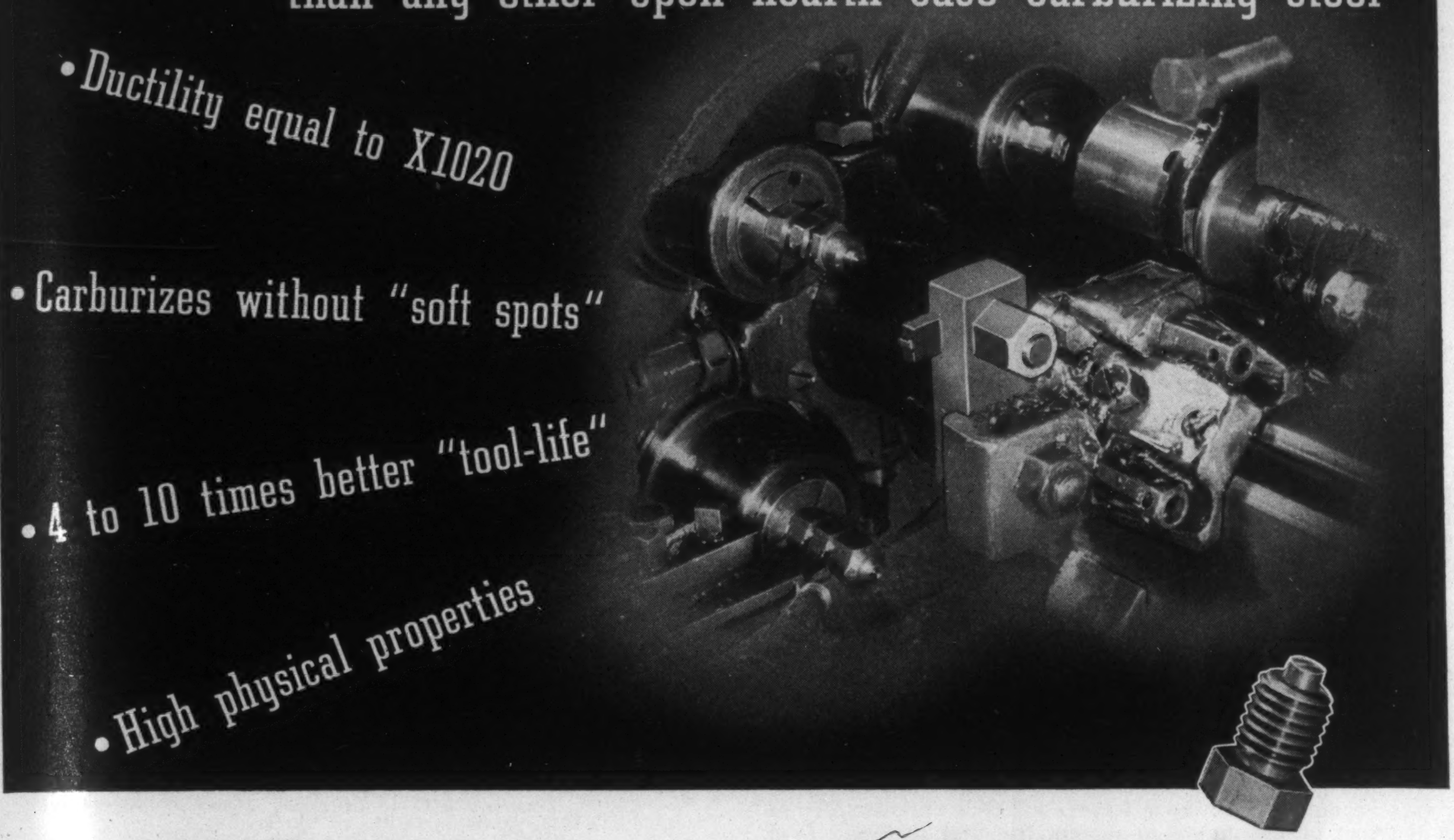
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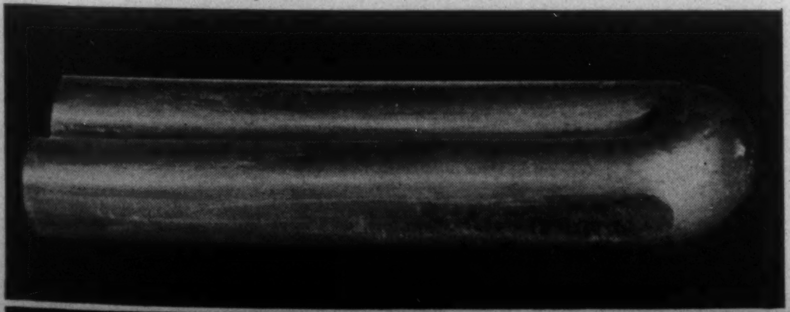

Despite approximately .24 per cent sulphur content, this 1 inch round, cold drawn, free machining .15-.20 carbon Speed Case steel bar was bent cold in a 150 ton press WITHOUT SIGN OF FRACTURE. (Photo is unretouched.)

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in another steel, containing 0.09% C, 0.85% Mn, 0.30% Si, 1.08% Ni, 0.10% Mo and 1.60% Cu, had practically the same properties as the base metal. An electrode (0.13% C, 0.50% Mo) with organic and mineral coating was used. Like other types of low-alloy steels, the Cu-Ni-Mo steels should be preheated if the C is relatively high (above 0.15%). Tensile tests on oxyacetylene welds in a steel containing 0.07% C, 0.84% Mn, 1.45% Cu, 0.97% Ni, 0.10% Mo have resulted in fracture in the base metal.

Copper is not a trouble maker in the welding of Cu steels. Consequently, there appear to be no pressing problems to suggest, aside from the general one of determining the mechanical properties that may be expected in welded joints made by different processes (including resistance welding) in the low-alloy structural steels containing Cu. 84 references. CEJ (2a)

Fabricating Stainless-Clad Steel

"Welding and Cutting of Stainless Clad Steel." W. B. Keelor (Farwell Metal Fabricating Div., Farwell, Ozmun, Kirk & Co.) *Paper, Am. Welding Soc.*, Oct. 1939. Descriptive review.

Stainless-clad steel is today being used extensively in the chemical, food, process and diversified industries to eliminate the necessity of frequent replacement of equipment due to corrosion; to keep products from becoming discolored or otherwise contaminated during the process of manufacture; and also for many decorative and architectural applications where the polished finish on the exposed surface displays all the advantageous features of solid stainless steel.

Electric metal-arc welding has been found to be the most practical welding method for stainless-clad steel, because welding temperatures can be kept low, cost is held to a minimum, and standard equipment available in most shops is entirely satisfactory. Sound welds may also be made with the oxyacetylene process, but it is difficult to control temperatures and therefore Type 347 Cb-stabilized stainless must be used if carbide precipitation in the weld area is to be avoided. Fabricators and users of stainless-clad steel equipment generally agree that corrosion resistance is retained when the electric metal arc process is used, in connection with correct welding procedure. The choice of a particular joint design depends upon the thickness of sheet or plate and the application for which the installation is intended. In some cases the steel side is welded first and the stainless side afterward, and for other types of joints the procedure may be reversed. It is always important, however, to leave a sufficient thickness of steel in the root of the groove to prevent the steel root-weld from penetrating into the stainless layer. Otherwise the resulting alloy deposit would not be sufficiently ductile.

High alloy electrodes such as 25 Cr, 12 Ni or 25 Cr, 20 Ni are preferred to 18 Cr, 8 Ni electrodes, since slight dilution by the steel does not lower the alloy content to a point where the corrosion resistance is unsatisfactory. Also, welds are invariably brittle when diluted to a point where the combined alloy content is less than 22%. The oxyacetylene cutting process is applicable to stainless-clad steel, although conventional procedure for cutting mild steel does not apply. It is necessary to cut from the steel side of the plate. Mechanical cutting machines are necessary because the cut, once started, must continue to its end without interruption. Should the torch be stopped before the cut is completed, it is very difficult to start again because of the oxides developed on the stainless portion. To start a cut at the plate edge, it is advisable to apply a small steel weld deposit directly on the plate edge, covering the steel and stainless portions. The cut should be started in this weld metal and continued across the plate with the torch inclined about 20° from perpendicular in the direction in which the cut is progressing. (2a)

Welding Galvanized Sheets

A Composite

Carbon-arc welding opens up a new field for the application of welded construction by making possible excellent results in the fabrication of galvanized steel lighter than 20-gage, according to G. G. Landis of Lincoln Electric Co. ("Carbon-arc Welding Process for Light Galvanized Sheets," *Welding Engr.*, Vol. 24, Sept. 1939, pp. 35-37). The procedure is described as providing an excellent bond, with minimum heat and least disturbance to the galvanized coating.

For satisfactory results, the carbon-arc welding of galvanized steel must be done with direct current using straight polarity. It is important to use a carbon that has a long thin taper; a 5/32-in. diam. carbon is suitable for use on thicknesses lighter than 16-gage, and for heavier material a 3/16-in. carbon may be used. The carbon is gripped in a holder about 1.5 in. from the point. The filler rod is usually a Cu-Mn-Si alloy such as Everdur, 3/32 or 1/16 in. in diam. Current for welding will vary from 50 amps. down to 20 amps. for the thin gages. The arc may be struck with the carbon anywhere on the plate and held until it becomes incandescent, but it should not be established until the carbon reaches the end of the filler rod. The ease of welding of various joints are listed in the following decreasing order: Offset lap joint, lap joint, butt joint, outside corner joint, and inside fillet.

Somewhat different is the procedure recommended by A. R. Eckberg ("Tin-coated Electrodes," *Steel*, Vol. 105, Oct. 23, 1939, pp. 52-53, 74) in a description of the Gaylord process for welding galvanized iron and steel sheet. According to him, carbon-arc welding with a straight Cu-Si alloy filler rod (as suggested above for light sheet) leaves a margin along the weld from which the zinc volatilizes, with consequent rapid rusting of the iron thus exposed. The Gaylord method, using carbon-arc and tin-coated Cu alloy filler rod has given excellent results.

In this process, the carbon tip is held about ⅔ of the way through the Cu alloy rod, which is laid flat in the fillet of the seam. While Sn melts at 231° C. and Zn at 419° C., the boiling point of Sn is 2260° C., and that of Zn is 907° C. As the latter temperature is more than 100° C. lower than the melting point of the rod (96% Cu, 25% Si, 1.5% Mn, melting point 1020° C.), the Zn volatilizes. Tin, having such a high boiling point, does not vaporize but remains liquid and deposits itself adjacent to the weld-metal. The carbon tip is moved along at a rate of 1 in. in each 5 sec. When the proper procedure is used, the bare iron is fully covered over with Sn at the same time the weld metal is deposited. Preece tests showed that such welded joints would withstand a 2-3 dip test in $CuSO_4$ solution. Microscopic examination indicates that the coating seems to be made of successive longitudinal layers of pure Sn with finally an alloy layer of Sn and Zn. If the correct procedure is followed, the total width of this entire area will be only 1/32-⅛ in. on each side of a weld on 16-gage galvanized sheet.

Like Landis, Eckberg believes the offset lap joint offers the best conditions for this process. This type of joint has about 90% of the strength of the galvanized sheet, with an average ultimate tensile strength of 51,000 lbs./in.^{2} The method permits changes in design of equipment, such as fewer hangers and the use of sizes large enough to allow frequent cleaning by actually sending men through the ducts. Total installation costs are about ⅓ lower than for conventional rivet-solder joint. X (2a)

Bright Annealing Transformer Steel

"Kinetics of the Decarburization of Transformer Steel While It Is Being Annealed in Hydrogen." B. D. Averbukh & G. I. Chufarov. *Metallurg*, Vol. 14, July 1939, pp. 48-61. In Russian. Research.

A method was developed for studying the decarburization of transformer steel while it is being annealed in H_2 at temperatures of 600°-1000°. The method is based on the manometric determination of H_2S, H_2O, and CH_4, which were collected at definite intervals by refrigeration. The speed of decarburization increased with increasing temperature, especially in the range between 600° and 800°. The addition of water vapor to the H_2 greatly decreased the speed of decarburization due to the formation of a film of SiO_2 which prevented contact of the metal with the H_2. By using a mixture of $H_2 + N_2$ the decarburization was greatly impeded and the quantity of N_2 in the gaseous mixture increased. The latter was due to the slower speed of reaction between the C of the metal and the H_2 as a result of a decrease in the partial pressure of the H_2. The process of decarburization proceeds in such a manner that the C diffuses to the metal surface where it reacts with the H_2 to form CH_4. However, it is the speed of the chemical reaction between the C and H_2 and not the speed of C diffusion to the metal surface which governs the process of decarburization. BZK (2a)

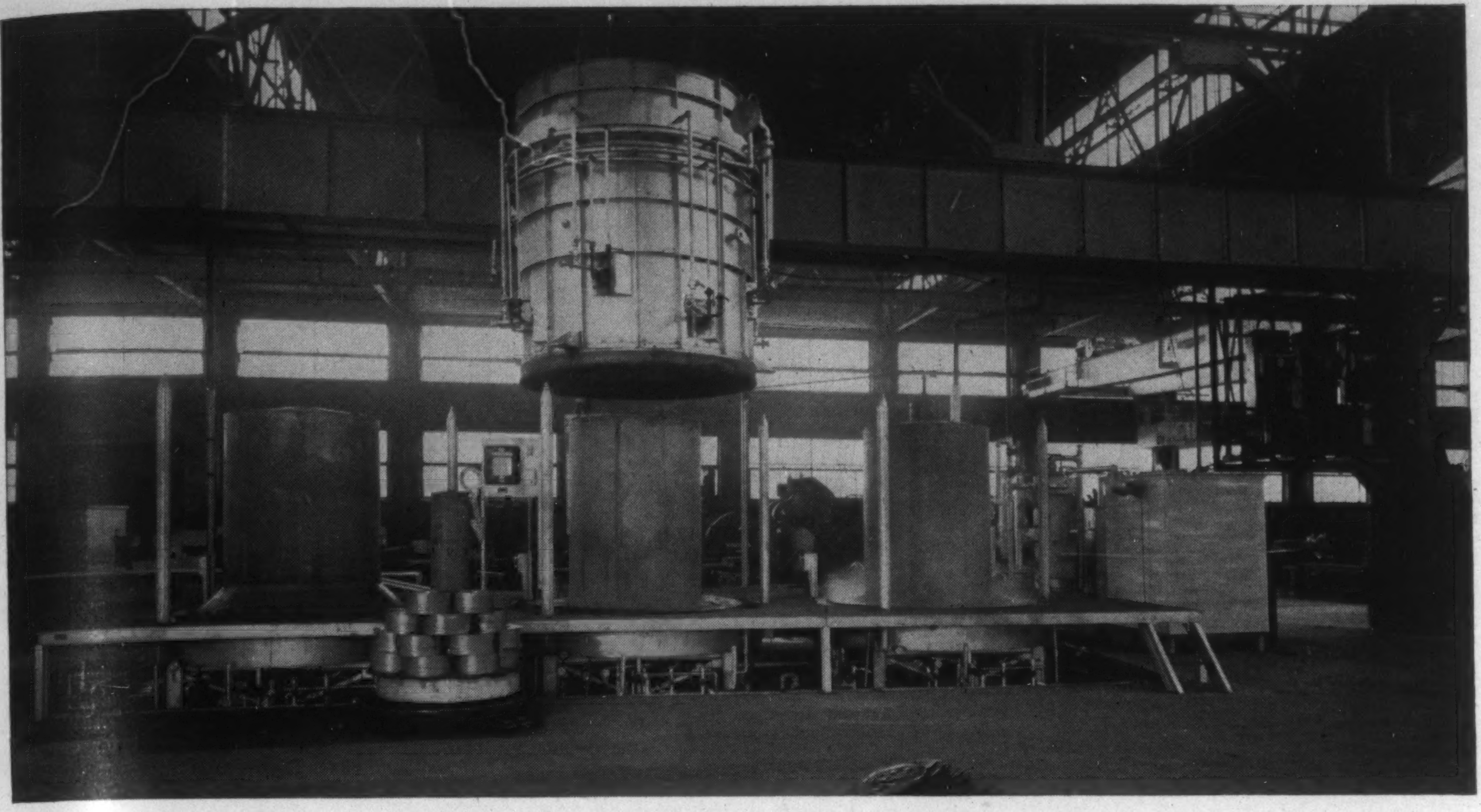
Heat Treating Cast Iron

Refining of Cast Iron by Heat Treatment ("Beitrag zum Vergüten des Gusseisens") O. Glaser. *Giesserei*, Vol. 26, Sept. 8, 1939, pp. 446-467. Practical.

Pistons for small rotary pumps were made of electrically-melted iron containing 3.1-3.3% C, 1.8-2.4% Si, 0.5% Mn, 0.6-0.8% P and 0.1% S, cast in ingot molds, annealed at 850° C., quenched in oil; and aged for several hrs. in oil. Whereas the former pistons of case-hardened steel showed growth after short time in service, the hardened cast Fe parts were very wear-resistant, kept their dimensions and maintained their hardness. The pistons showed the following characteristics:

Piece	Total	Graphite			Brinell Hardness	
No.	C	annealed	hardened	Si	annealed	hardened
1	3.23	3.10	2.49	2.12	174	461
2	3.21	3.11	2.51	2.17	182	421
3	3.31	3.18	2.75	2.37	194	388

A comparatively short heating of the iron dissolves a sufficient amount of graphite to obtain, in the subsequent hardening process, a structure that is both heat-resistant and permanent as to dimensions. Ha (2a)



Indirect-fired bell type furnace, operated with Gas, in the plant of Revere Copper and Brass, Incorporated, Rome, N. Y. Photograph courtesy Surface Combustion Corporation.

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Revere Copper and Brass, Incorporated uses controlled atmosphere GAS furnace for bright annealing copper

This indirect fired bell type furnace was recently installed in one of the plants of Revere Copper and Brass, Incorporated, Rome, N.Y., for bright annealing copper and clean annealing brass in coils. The furnace has a maximum capacity of 12,000 pounds per load. Actual test data showed the fuel consumption—530 b.t.u. gas—to be between 0.35 and 0.49 cubic feet per pound of metal, depending on temperature and loading.

A specially prepared atmosphere composed of refined products of combustion is used to protect the metal from scaling and discoloration during the heating and cooling cycles. As removed from the furnace, copper is perfectly bright and ready for shipping. Because of the controlled atmosphere, no pickling or cleaning is necessary.

Grain size is held consistently within plus or minus .005 millimeters in any one heat. This close control of grain size improves the drawing properties of the sheet and is an indication of very uniform heating—a job that Gas performs superlatively in all phases of heat treating.

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Welded Boiler Drums

"Examinations and Tests for Fusion Welded Boiler Drums." L. W. Schuster. *Trans. Inst. Welding,* Vol. 2, July 1939, pp. 151-161. Review of British specifications.

In general, British specifications for welded boilers are similar to American practice, but some new viewpoints are presented. In the section on Constructional Details and Preparation for Welding reference is made to a clause in the specification that requires that misalignment of abutting plates for butt welds at any longitudinal seam shall not exceed 1/16 in. for plates up to ⅝ in. thick, and a further margin of error of 1/64 in. is allowed for each ¼ in. additional plate thickness. The maximum permissible misalignment is ⅛ in. The reasons for these specifications are that misalignment causes an undue stress at the joint owing to the bending moment set up and that the accompanying departure from the level at the surfaces of the plate causes a concentration of stress at the re-entrant angles. There is no special requirement for welding beyond stating that the weld be made by the metallic-arc process, that the welding edges be free from scale, rust, oil or other foreign matter, and that butt welds are to be made from both sides of the plate, after chipping, grinding or machining out the metal at the bottom of the first side welded. It is specified that additional runs of metal be deposited at both outer surfaces of welded seams, in order to refine the lower runs of weld metal lying level with the surfaces of the plate; the outer runs of metal are afterwards machined or ground away flush with the plates.

The heat treatment specified in stress-relieving treatment is to heat the entire drum slowly to 600°-650° C. and cool in still air on removing from the furnace. The author prefers the term "low-temperature annealing treatment" to stress relieving treatment since it is his opinion that the latter term tends to divert attention from the fact that the treatment is also conducive to the coalescing of pearlite and the separation of nitrides. It is important that test pieces receive the same heat treatment as the vessel, especially with respect to the weld metal. If the weld metal is contaminated with nitrogen it may be air-cooled from 400° C. without precipitating needle-like nitrides whereas furnace-cooling to room temperature causes the nitrides to be rejected.

Test pieces are selected from the test plates for longitudinal seams, for which the following tests are made: (1) *Tensile test on all-weld-metal* specimen for which the specifications are (a) tensile strength not less than the lower limit of parent metal, (b) elongation not less than 20% on a gage length of 4 times the square root of the cross-sectional area of the test length, and (c) reduction in area not less than 35%. A retest is permitted as long as the reduction in area does not fall below 30% and the other figures do not fall below 90% of their specified value. (2) *Tensile test of welded joint* made from full width of welded seam, if possible, and tested as a rectangular test piece. This test is considered of importance as a test of the weld metal and imperfections at the junctions. No measure of ductility is made. (3) *Bend test on welded joint,* face and root bends are made and are considered to be useful for detecting weakness at the top and bottom of junctions and observing the behavior of parent metal in the heat-affected zone.

Other tests include: (4) *Impact (Izod) test on welded joint,* which is required to yield a minimum value of 30 ft.-lbs. for one notched specimen with the notch at the middle of the top surface of the weld and for another with the notch at the middle of the lower surface. The test is for the weld metal and is used as a check against the presence of undesirable metal. Notching at the junction of the weld is considered to be unreliable since the specimen may crack by diversion into the parent or weld metal. (5) *Specific gravity test* on weld metal should give a minimum value of 1.88. (6) *Micro and macro examination of cross section,* which are useful in determining the cause of a defect and judging the extent to which the defect is detrimental. (7) *Radiographic examination* of the joint. (8) *Hydrostatic and hammer test* and (9) *Tests for circularity* of the vessel. WB (2a)

Dissimilar Welding Electrode, Parent Metal Combinations

"The Effect of Alloying in Metallic Arc Welding." R. W. Emerson. *Welding J., N. Y.,* Vol. 18, Oct. 1939, Supplement pp. 381-392. Original research.

The welding of low-C steels with electrodes of 18-8 and 25-12 alloy steel and the welding of plates of the latter two compositions with low-C steel electrodes were investigated by means of hardness surveys and microstructurally. Because of the high temperature of the molten metal in the pool and the turbulence therein the metal that is melted from the kerf surface (of low-C steel plate) is effectively alloyed with the stainless deposited metal throughout the entire cross section of the bead. Because of this fact the author states that the concept previously established of the existence of a narrow band of martensite adjacent to the parent metal (low-C steel) with the major portion of the weld bead consisting of austenite, is incorrect. When the dilution of the weld metal by the parent carbon steel is sufficient to lower the alloy content of the former to unstable austenite, the entire bead will revert to martensite.

The evidence is given in numerous microstructures of welded plates and hardness surveys across the parent metal and weld deposit. The properties of low-C steel, 25-12, 0.27% Cr, 0.17% Cr, 12% Cr, and 18-8 steel plates welded with various low-C steel and alloy electrodes are tabulated as determined by the author in tensile tests and free bend tests. When low-C steels are required to be welded with alloy electrode the recommendation is made to use the 25-12 or preferably the 25-20 electrode rather than one of 18-8 grade. WB (2a)

Precision Projection Welding

"Precision Welding by the Resistance Method." G. J. Oswald, E. J. Bates & R. L. Hous (National Cash Register Co.) *Welding J., N. Y.,* Vol. 18, Oct. 1939, pp. 581-587. Practical.

The physical requirements, equipment balance and fixture design for obtaining precision are discussed at length for resistance welding by the projection method. In welding assemblies, dimensions are held accurate to 0.001 in. through the use of smaller, more accurate projections and a welding technique that produces the maximum strength of joint without undue distortion of parts. The parts to be welded have commercially clean cold-rolled and cold-drawn or machined surfaces, and thus require lower projection heights and welding pressures than where rust or scale are present. The projection dimensions in general use are tabulated and the opinion is given that 30% smaller dimensions than those in use would be better because the distortion during welding and during formation of the projection would be considerably less than for the practice tabulated. Test data are cited for experimental runs to determine the effect of decreasing height of projection as follows:

Height of projection	.040	.030	.020	.010
Diam. of projection	⅛	⅛	⅛	⅛
Av. weld strength in lbs.	5,300	4,980	4,500	3.800
Area of weld, in.^{2}	0.188	0.166	0.160	0.131
Weld strength, lbs./in.^{2}	27,700	30,000	28,100	29,000

These values prove that the strength of the weld depends upon the effectiveness of the grain growth and recrystallization across the joint of the weld. The size of the area covered by this grain growth and recrystallization is the most important factor in determining the strength of the weld. The pressure need be sufficient only to break through any film that may be present on the surfaces to be welded and to force the metal into intimate contact for a sufficient length of time for such grain growth to take place.

It is, therefore, possible that some of the high forging pressures used in projection welding of light weight parts having commercially clean surfaces may be excessive. A series of tests were made on commercial S.A.E. 1010 and 2315 strip steels of differing thickness, which were welded under various conditions of heat input and pressure; the successful conditions on a strength basis are tabulated for the cold-rolled and for case-hardened strip steel. WB (2a)

Better Gas Welds with Modified Welding Rod

"Experiments with New Welding Rods for Gas Fusion Welding" ("Versuche mit neuartigen Schweiss drähten für die Gasschmelzschweissung") G. Stieler. *Autogene Metallbearbeit.* Vol. 32, Oct. 15, 1939, pp. 297-307. Descriptive review.

The notch-impact values of gas welds are stated to be, in general, not quite so satisfactory and high as those of electric welds. A thorough review is given on this subject with tables showing how these values may change with different types of base material and welding rods. Whatever the method, special care or subsequent treatment has to be applied to obtain satisfactory results.

Recently, certain welding rods have been developed which gave with plain carbon and low-alloy structural steels notch-impact strengths of 8 kg./cm.^{2} or higher with the ordinary progressive welding method and without any subsequent treatment; the former values were much below this. The composition of the welding rod was scarcely different from the rods now in general use, except that it contained 1.25% Mn and about 0.5% Ni. The Mn content of the weld metal was as high as about 0.8%, while the Ni content of the weld was practically the same as that of the rods. Welds made with this rod could be bent 180° without cracking or fracture. One other wire contained 3% Ni; with this, the elongation at fracture was higher, and reduction of area was as high as 44%. All the new welding rods gave a more uniform notch-impact strength, the ratios of the lowest to the highest values running between 1/1.15 and 1/1.35, while in the previous methods it was as high as 1/1.8. Using the new rods results in a rather coarse grain but this does not seem to be harmful in subsequent service. Ha (2a)

Welding in the Railway Field

A Composite

Advances in the application of welding to a number of problems in American railway practice and the present position of rail and railway-equipment welding in Germany are separately reviewed in two recent articles. Both emphasize the prominent part welding now plays in railroad operation through more efficient maintenance of way practice and increased safety and riding comfort.

A descriptive survey of maintenance-of-way welding is given by C. E. MORGAN ("Maintenance of Way Welding", *Welding J., N. Y.*, Vol. 18, Oct. 1939, pp. 631-632). The build-up of rail ends to resist batter is now done by means of both gas and arc welding and it has been found that hardnesses of less than 320 Brinell are not effective in preventing batter. The welded rail with a hardness of 450 Brinell is found to exceed in ductility any rail in its "as rolled" condition. Hardnesses of 350 to 400 Brinell are aimed at, although the opinion is that hardness is not directly proportional to resistance to batter. When arc welding is used for build-up, the rail ends are preheated to 500° F. and welding is done with ¼-in. to 5/16-in. electrodes. It is stated that the ideal welding rod for this work is not yet available; the rod used should have a light coating, and should be 24-30 in. long with the holder gripping the rod in the center to reduce loss of material in stub ends and loss of time in changing electrodes.

The electric arc is used exclusively for build-up of worn frogs and crossings of Mn steel, and the practice is meeting with considerable success. Previously the combination of poor welding technique and Mn steel castings of poor quality produced poor results, but improved foundry work and better design have contributed to present success. Other fields for welding are in rail-end welding, bridge-welding, repairs to existing structures and new construction.

Many examples of the experience of the German State Railway in gas welding new track and in building-up worn and defective rails are given by R. DÜMPELMANN ("Entwicklung der autogenen Schienenschweissung", *Autogene Metallbearbeit,* Vol. 32, Sept. 15, 1939, pp. 278-282). Butt welding of the rail joints does away with the stresses resulting from the use of bolted lap joints, so that fewer repairs are necessitated. Fatigue tests of such joints welded with carefully selected welding rods showed that no fracture occurred after 3×10^6 cycles at about 28,000 lbs./in.^{2} stress. Metallographic examination disclosed that even "very hard" rails (285 Brinell) can be autogeneously welded successfully, and without loss of hardness; in fact, one test weld had a hardness of 340-380 Brinell in the weld and on the surface. The head of the rail used in the test was of steel with 0.7% C, 0.32% Si, 0.40% Mn, O.62% Cr; while the web and foot material was somewhat softer, with 0.18% C, 0.28% Si and 0.40% Mn.

X (2a)

Flame Hardening Small Parts

"FLAME HARDENING SMALL PARTS." T. A. FRISCHMAN (Eaton Mfg. Co.) *Heat Treating Forging,* Vol. 25, Sept. 1939, pp. 445-446, 458. Practical.

In addition to flame hardening large parts, this method can be applied to small objects where older and more common methods fail to develop the desired characteristics. The application of the method to 2 specific parts is described. The first, a clutch actuator cam, must possess a hard cam track yet undergo little distortion in heat treatment. S.A.E. 3150 steel is used and if hardened all over by heating the entire part above the critical point and oil-quenching on a fixture, too much distortion occurs to obtain a snug fit of the threads. By flame hardening only the cam tracks, a much better product resulted, with improvement in manufacturing operations since threads can be cut after hardening the track. Distortion was reduced to practically nothing. The flame hardening machine was installed directly in the machining line eliminating transportation to and from the heat treating department. Cleaning was also eliminated.

The machine consists essentially of a mechanism which rotates the cam in a horizontal position. The torch is mounted on a roller, which follows the cam track, the flame being halfway around the cam from the supporting roller. An air-blast is directed against the heated cam directly behind the flame. Those parts that are not desired hard are constantly submerged in water during the heating cycle. In order to duplicate results, it is necessary to control the gas pressures, distance of flame from work, type of flame, and depth of submersion of part in water. The speed of travel of the work is regulated to give a temperature of 1550° F. Microscopic examination of the cam shows that the track is completely martensitic at the surface, troostitic somewhat below, and gradually blends into the original annealed structure of pearlite and ferrite.

Another part that is flame hardened is the bridge between the detents of a heat-treated malleable iron shifter fork. This part

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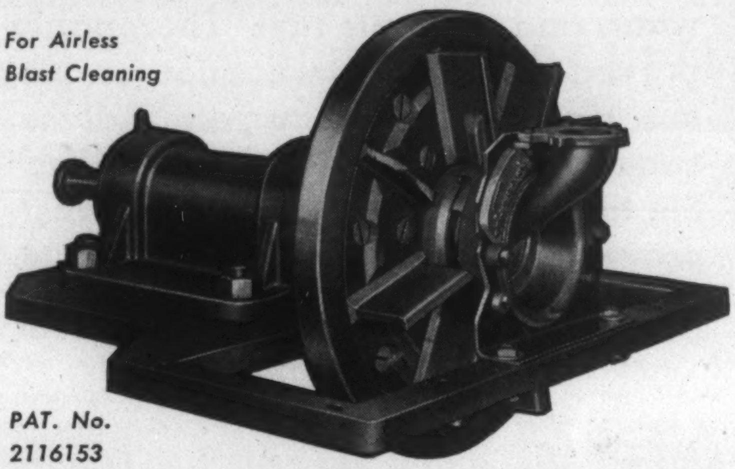

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now is fabricated completely in the machine shop. The machine used is designed to permit the flame to play upon the bridge for 9 sec. Forks rotate on a table equipped with many vertical pins on which forks are slipped. By a cam arrangement, a torch applies heat to the bridge for a given time, whereupon the torch is released to return to its original station. No quenching medium is used as the cold under-lying material abstracts heat fast enough to quench out the bridge to a file-hard surface. Microscopic examination in this case reveals practically 100% martensite with temper-C in solution. This structure continues part way toward the interior, whereupon there appears some of the original graphite surrounded by martensite. This latter structure in turn blends gradually into the original structure of heat treated malleable iron. Wear resistance was improved over that resulting from the former practice of heating all over in an energized salt-bath. MS (2a)

Grooving Steel with the Oxyacetylene Flame

"Flame Gouging: An Economical Method of Grooving Steel." H. E. Rockefeller (Linde Air Products Co.) *Iron Age,* Vol. 144, Sept. 14, 1939, pp. 53-57; Sept. 21, 1939, pp. 50-52. Practical.

Flame gouging is an oxyacetylene process applicable to rolled, forged and cast carbon steel of 0.35% maximum C. The process consists of quickly removing a narrow strip of surface metal from steel plate, forgings and castings. Using a nozzle delivering a relatively large jet of oxygen at low velocity a smooth and accurate groove can be cut. By using different nozzles and manipulations grooves may be varied in width and depth.

The uses of gouging are: (1) Gouging the back side of electric welds; (2) removal of excess weld metal; (3) maintenance and scrapping operations; (4) plate-edge preparation; and (5) miscellaneous uses. Applications of these 5 types are described. Steels that can be gouged are listed under sections S-1, S-2 and S-26 of the A.S.M.E. boiler construction code, which cover plate used for boilers and pressure vessels. In general, these are high tensile strength plain carbon steel plates 2 in. and under in thickness and having a maximum C content of 0.35%. The code is similar to A.S.T.M. and A.P.I. codes.

Gouging should not be applied to air-hardening steels where the added hardness from the operation will be objectionable. Alloy steels should be tested before gouging by experimenting on scrap pieces. Good results are obtained on cast steels, but cast iron cannot be gouged. In gouging malleable iron it should be remembered that the heat of the operation will destroy the malleable properties and produce a hardened zone about the cut.

2b. Non-Ferrous

Rhodium Plating

A Composite

Rhodium plated articles possess an unusual combination of reflectivity, hardness and wear resistance, corrosion resistance, and simple beauty, and give good service with relatively thin plates. The most common applications of Rh plating have been for the finishing of ornamental articles, for the preparation of mirrors in scientific apparatus, and for the surfacing of high-powered reflectors for flood- and search-lights.

The preparation of Rh mirrors for technical measuring instruments is described by M. Auwärter ("Rhodium Mirrors for Scientific Purposes," *J. Applied Physics,* Vol. 10, Oct. 1939, pp. 705-710). Methods of obtaining optical reflecting surfaces of various types are discussed and curves are given showing the reflecting powers of Al, Ag, Si, Pt and Rh over the wavelength range 2,200-8,000 A.U. and in three different states: Freshly prepared, physically aged, and chemically aged. Although inferior in reflecting power to both Al and Ag in most of the visible range, Rh has a greater constancy of reflecting power in this range. Furthermore, all of the metals except Rh are subject to physical and chemical aging, which is detrimental in precision optics. Rhodium is also more temperature-resistant than other metals; a Rh mirror may be used at temperatures up to 430° C. The use of organic and other protecting coatings on mirrors is discussed and it is stated that Rh is the only metal which can retain its reflectivity unimpaired for any length of time under atmospheric conditions.

Other unique advantages of Rh are its great hardness permitting cleaning with soft cloths and its exceptional adhesion to the supporting material. It is also found that Rh is superior to Pt for semi-transparent films. The fraction of light transmitted by a Rh film remains more constant over the visible range than in the case of Pt. Technique has been developed for producing Rh coatings on surfaces up to 1 in.^{2} in area with a constancy of transmission of 5% or less over the surface.

Additional physical property data are given by A. Bregman ("Rhodium Plating; Properties, Applications, Plating Practice and Costs," *Iron Age,* Vol. 144, Nov. 9, 1939, pp. 31-33), who also reviews commercial plating practice. The melting point of Rh is about 1970° C., and its specific gravity is 12.4. It is white in color and can be given a high luster. Rhodium plates are very hard, 594-641 Vickers, as compared with 130 for Au, 155-420 for Ni, and 500-900 for Cr. Its reflectivity is high and it is non-tarnishing, and primarily for these reasons it is used as reflecting surface for light reflectors. The first patent involving its electrodeposition was issued in 1912, but the art was not really developed until 1930.

The solutions used in present commercial practice are: (1) Sulphate, (2) phosphate, or (3) mixed sulphate and phosphate. All the solutions contain about 2 g. of Rh/l. of solution. Opinions differ on the advantages of different types of solutions. The general practice today is to purchase prepared concentrated solutions and to keep the bath up to strength by additions. Rhodium-plating solutions are controlled primarily by testing for metal content; the most accurate tests in practical use are colorimetric. Platinum anodes are used. Foreign matter, especially organic material, must be kept out.

The deposits are often as thin as 1 mg./in.^{2}, or 0.00005 in. thick. The stripping of Rh plate is difficult. The cost of installation of a Rh-plating unit, based roughly on the basis of a 6-gal. solution, will amount to about $800. The cost of Rh at its present price is from $170 to $218/oz. in solution form, amounting to $\frac{1}{2}$c/in.^{2} for a 1-mg./in.^{2} deposit. On such a basis the cost of current is practically negligible. VSP (2b)

Continuous Annealing of Non-ferrous Wire

"Continuous Wire Annealing in Open Gas Flames." Harry W. Smith (Am. Gas Assoc.) *Heat Treating & Forging,* Vol. 25, Oct. 1939, pp. 513-516; *Steel,* Vol. 105, Oct. 2, 1939, pp. 44, 46-48. Descriptive.

New process and equipment developed by Syncro Machine Co., Rahway, N. J., and Surface Combustion Corp., Toledo, Ohio, for continuously and very rapidly annealing and tinning strands of Cu and brass wire, without furnace or atmosphere tube, are described. The units can handle No. 6 to 36 B. & S. gage wire. Those with 9-ft. burners are capable of speeds up to 225 ft. per min. on No. 14 strand. The 27-ft. burner models can triple that speed. On the smallest sizes of wire speeds up to 1500 ft. per min. can be reached with 4$\frac{1}{2}$-ft. burners.

The apparatus consists of a long row (2-27 ft. of accurately controlled gas flames placed end to end to form the compound burner length. Positioning dies are spaced along the row of burners so that the wire passes through just that portion of each flame in which combustion has advanced exactly to the point where both temperature and composition are just right for annealing. Each flame is $4\frac{1}{2}$ in. long and as thick as the slot (0.03-0.06 in.) through which mixed gas and air pass into the combustion zone. Annealing is adjusted either by the height and character of the flames or by the speed of wire. The entire burner assembly is enclosed in a sheet-metal hood for protection against drafts. The air-gas ratio is almost exactly that theoretically required for complete combustion. A 9-ft. burner will consume about 80 ft.^{3} of manufactured gas per hr.

The wire from the supply reel passes over a push-pull capstan and travels through an elongated feed-tube to an idler pulley at the other end of the line, and then through a wire-brush cleaner. The same capstan carries the delivery sheave, which is slightly larger than the feed sheave, so that the wire in the entire line is always under a tension that will produce about $\frac{1}{2}$% elongation. The wire passes from the delivery sheave on to a traverse and idler-pulley combination which feeds it to the finish reel. The cleaned wire passes through the annealing flame and then either directly through a water-quenching tube or through a special continuous pickling, tinning, wiping and burnishing equipment before being quenched. Restrictions at either end of the quenching tube are fitted with suction offtakes to prevent water leakage.

The wire dries rapidly by its own heat or by compressed air jets, and then passes through a device which continuously indicates and controls the degree of annealing. The latter consists of 2 fixed wheels over which the wire passes and between which it is depressed by a floating wheel. This wheel rides in a ball-bearing that rides on longitudinal rods located behind a scale bar. The floating wheel has a tendency to move forward from its normal mid-position between the fixed wheels with the forward motion of the wire. The degree to which it floats forward is an inverse index of the hardness and, therefore, a measure of the annealing. The scale used can be calibrated against actual elongation tests.

For continuous pickling, the wire passes through a Pyrex glass cell into which are injected dry chlorine and other vapors at 500° F. Then it passes through a special cast iron channel into the side of which molten tin at 500° F. is pumped under low pressure to flow out either end and be retrieved. Tinned wire is wiped in the hot zone by a long spring, and is burnished in the open air by a similar spring. This method produces a most acceptable uniformity of annealing with a very clean, bright surface, and is considerably cheaper than any other method. During full operation, consumption of manufactured gas averages $\frac{1}{2}$ ft.^{3} per lb of wire annealed. MS (2b)

A New Resistance Welding Process

A Composite

A new resistance welding method—novel in that it is a fusion process without pressure application—of special value for nonferrous welding has been developed by Weibel in Germany. Details of the method (officially known as the FESA-Weibel process) and some practical experience with it are reviewed in two recent articles in German magazines.

The process is particularly advantageous for welding thin sheet because the welding temperatures used in general are never higher than 1,500° C., as compared with 3,000° C. reached by the oxy-acetylene flame, according to K. GABLER ("Das FESA Schweissverfahren, System Weibel," *Metallwirtschaft,* Vol. 18, Sept. 30, 1939, pp. 817-820). He describes the process as resistance fusion welding though in contradistinction to spot welding no pressure is applied. The equipment used somewhat resembles a soldering iron. In practice the primary side of the welding transformer can be energized by 220, 380 or 500 v. Voltages on the secondary side run from 3.5 to 8 v., with currents from 80 to 300 amps. The secondary current is fed through flexible cables to 2 carbon electrodes. In the actual welding process the thin sheets are flanged and the carbon electrodes are drawn over the flanged edges, melting them. Butt welds, however, can also be made by drawing the electrodes over a wire laid on top of the sheet edges to be joined. A small amount of flux is required. For 0.1 mm. sheet a flange 1.0 mm. in height is required; for 0.1-0.4 mm. thickness, a 1.0-1.5 flange; for 0.5-0.1 mm. thickness, a 1.5-2.0 mm. flange; and for a thickness of 1-2 mm., a 2-2.5 mm. flange. Welding speed on the average is 0.5-1.5 meters/min. Aluminum and Mg alloys, lead and zinc up to 2 mm. in thickness, and copper sheet from 0.1 mm. to 0.8 mm. have been successfully welded by this process.

An appraisal of results obtained by the new method as applied to thin Al alloy sheet is presented by E. VON RAJAKOVICS ("Erfahrungen mit einem neuen Schmelzschweissverfahren für dünne Bleche," *Maschinenbau Betrieb,* Vol. 18, Aug. 1939, pp. 395-398). Pore-free and dense weld-structures are obtained, because of the absence of the blowing effect that occurs in gas and arc welding. In Al alloys the Weibel process yields tensile values equal to the Arcatom process and sometimes better than gas welding. The maximum sheet thickness for good strength properties is 0.8-1.2 mm. The heated zone is smaller, and the temperature is lower

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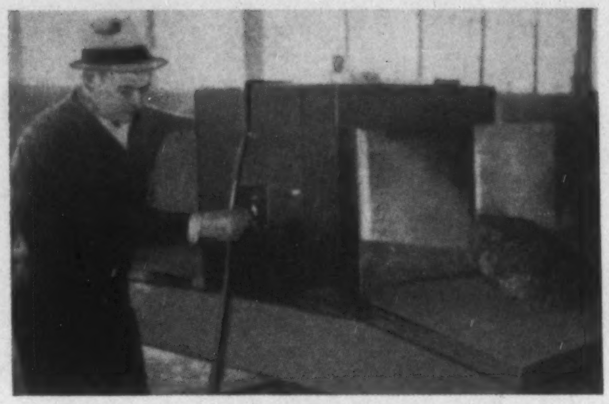

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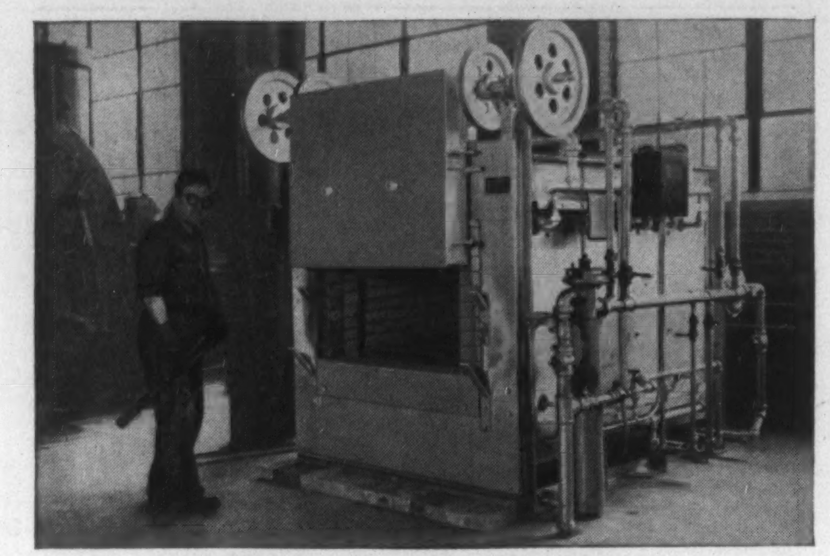

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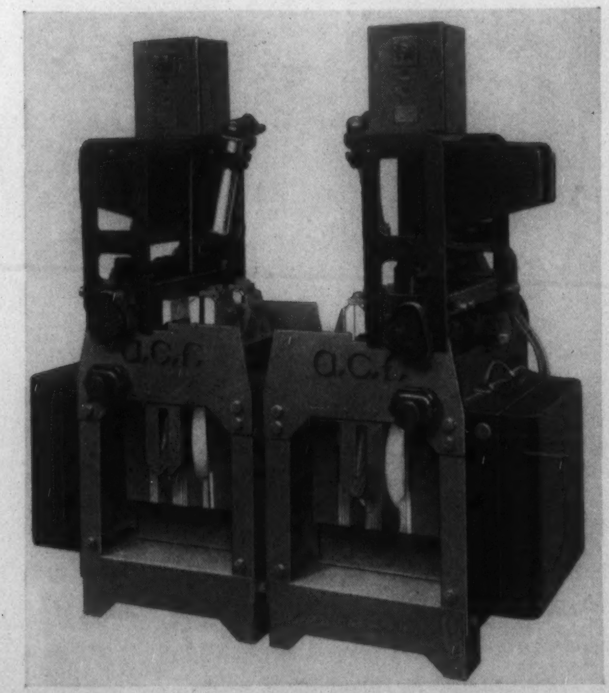

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than with the oxyacetylene method. The corrosion resistance of welds made on some Al alloys by the Weibel method is superior to those made by Arcatom welding, and in one case also to oxyacetylene welds.

The method cannot be used for steel. X (2b)

Surfacing Light Metal Pistons

"Improving the Running Properties of Light Metal Pistons." ("Ein weiterer Fortschritt auf dem Wege der Verbesserung der Notlaufeigenschaften der Leichtmetallkolben") E. Nitzsche, *Metallwirtschaft,* Vol. 18, Oct. 20, 1939, pp. 848-851. Descriptive.

The running properties of lead-plated aluminum pistons are compared with tin-plated, anodized and untreated pistons. The lead-coated pistons were treated by the Perner process, which consists of producing a metal deposit by a chemical reaction between the immersed aluminum object and the metal ions in the bath, the reaction taking place at 20° C. The results are a dense adherent lead deposit on the aluminum piston. It is reported that film thickness can be easily controlled in this process, and that lead deposits as thick as 0.020 mm. are uniform in thickness.

Tinned, leaded, anodized and bare pistons were tested in cold-starting tests where the cooling water was at —15° C. and the oil at —11° C. After the start the motor was immediately braked while running with full load at 2,000 r.p.m. The starting test lasted 2 min. in which time the coolant was warmed to 60° C. The cold-starting tests were repeated at intervals of 3 hrs. After 12 starts the untreated pistons were scored or had seized. The lead-coated pistons stood up the best followed by the anodized and tinned pistons.

Actual service tests consisting of driving a car equipped with lead- and tin-plated pistons for 625 miles indicated the superiority of the lead-plated pistons in that damage to the film was less. Production experience with the tin coating process shows that 1 kg. of sodium stannate is needed for 100 pistons. In the Perner lead bath 1 kg. of a complex Pb salt (50% Pb) is needed for every 100 pistons. GA (2b)

Spot Welding Pressure Control

"Pressure Control in Spot Welding of Non-Ferrous Metals." Richard H. Taylor (Electroloy Co.) *Welding Engr.,* Vol. 24, Sept. 1939, pp. 62-63, 71. Practical.

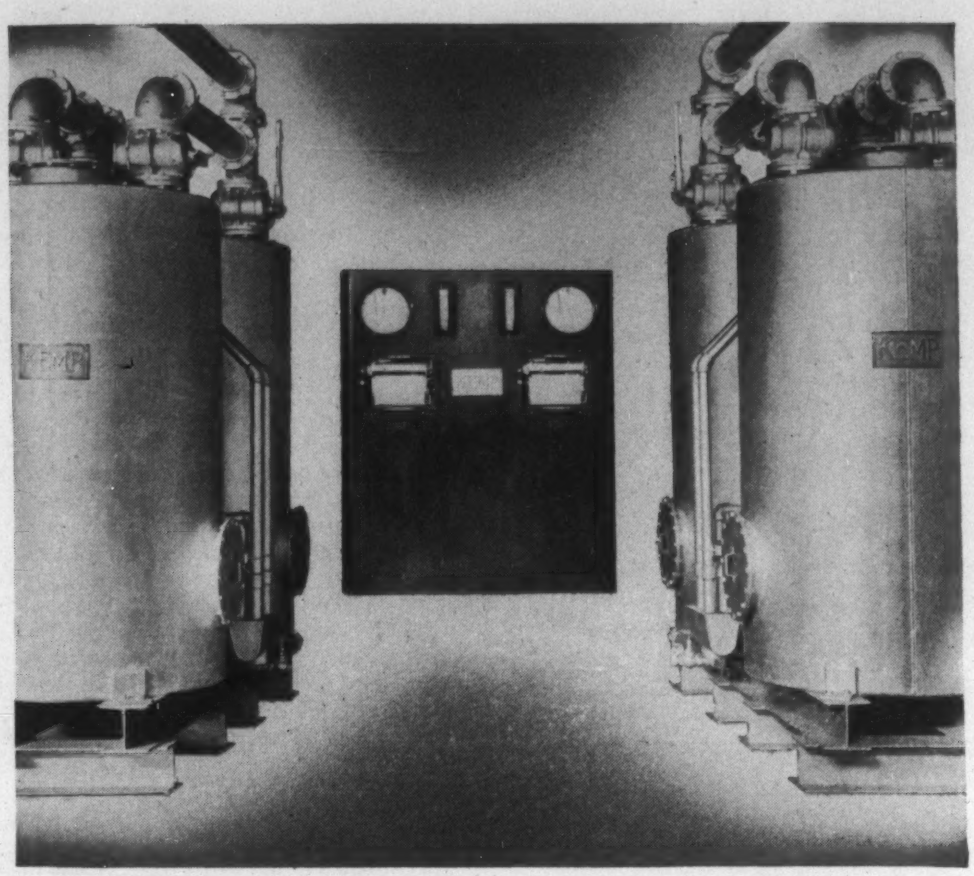
All variables in spot welding should be controlled within close limits to insure consistently good welds. The more important of these variables are: The material to be welded, the voltage and amperage used in welding, the shape and contact area of the electrode, the time current is allowed to flow, and the pressure. The first 4 of these are usually recognized and taken care of with suitable control. However, merely controlling the amount of pressure on the electrode does not necessarily bring about the desired result, for the speed of application of pressure is also important.

Rapid starting can occur only when the pressure/mass ratio is 10/1 or greater. If the weight of the electrode, electrode arm, head and flexible end of the secondary totals about 150 lbs. it would require a pressure of 1,500 lbs. to produce moderately quick starting. Such pressures, however, can not be used for non-ferrous metals. This difficulty is surmounted by using an electrode holder of recent design that acts independently of the head of the welding machine and which provides a movable element of very light weight. The weight of the moving part is usually between 1 and 2 lbs., and will move much faster than the electrode on the average spot welder. A lower kv.-a. rating was possible. CEJ (2b)

Blistering During Heat Treatment of Aluminum Alloys

The Correct Interpretation of Various Phenomena Noted in the Heat Treatment of Aluminum Alloys ("Sulla corretta interpratazione di taluni fenomeni che si possono verificare durante il trattamento termico delle leghe di alluminio") Carlo Panseri & Marcella Monticelli. *Alluminio,* Vol. 8, July-Aug. 1939, pp. 183-191. Trouble-shooting research.

A casting of Y-alloy, whose surface was badly blistered, was examined to determine the cause of the blistering. The analysis of the alloy was 4.45 Cu, 0.205 Fe, 0.415 Si, 1.183 Mg, 1.935% Ni, remainder Al. Sections cut through the blisters and etched with 0.5% HF showed clearly that a liquid had been formed in the core under pressure, and that this liquid had forced its way to the suface where it had solidified as blisters. Heating sections of the alloy up to 550° C. duplicated these results, *i.e.* at this temperature some fusion resulted; this alloy should not be heated over 510°-520° C. Poor control in the heat treatment was described as the cause of the blistering. AWC (2b)



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High Temperature Behavior

The Structural Mechanism of the Mechanical Behavior of Metals at Elevated Temperatures ("Recherches sur le Mécanisme Structural du Comportement Mecanique des Métaux aux Températures Élevées") G. A. Homés. *Rev. Mét.*, Vol. 36, Aug. 1939, pp. 373-388. **Review plus research.**

The extension and change of internal structure were determined for copper and for mild steel at various temperatures up to 600° C., under various stresses, and for times up to 1000 hrs. In any case, below a certain temperature, the metal work hardens with increasing creep, while above a certain temperature, the metal is always recrystallized. The applied load determines whether specimens at intermediate temperatures will be recrystallized or not. All the results are said to be explainable by the combination of two processes: Plastic deformation due to the load, and recrystallization due to the temperature. There is no correlation between the creep curve and the structure of the metal.

It is possible to accelerate or decrease the tendency toward recrystallization by judicious additions to pure metals, as was shown by tests on various ferrous materials, including Armco iron, and Cr-Mo, Cr-Mo-Al, 2.2% Ni, Cr-Ni, Cr-Ni-Mo, and Cr-W-V steels (analyses not given), after long time holding between 300° and 600° C. While some steels are more stable than others, the initial heat treatment exerts a great influence on the stability of the structure. There is a rapid change in quenched-and-tempered specimens if the tempering temperature was lower than the test temperature. In general, Ni accelerates structural change, while Mo hinders it. In a creep specimen, all the crystals are not deformed by the same process. A perceptible change of structure is less important in creep than slipping by translation. The rapidity of loading plays an important role also. A specimen can be ruptured at elevated temperatures without any apparent change in the structure.

The following procedure is suggested for testing materials for use at elevated temperatures: (1) Scaling tests under conditions simulating those to be encountered in service, for the simple purpose of eliminating non-resistant materials; (2) structural stability tests for further elimination of alloys that will not retain their original structure (and therefore original properties) after long time exposure; and (3) determination of maximum temperatures and loads that alloys not eliminated in (1) and (2) will withstand without excessive creep. Often further tests such as elevated temperature fatigue in corrosive media are necessary to ascertain factors of safety. Short time tests are not reliable.

JZB (3)

Soil Corrosion

"Soil-Corrosion Studies, 1937. Corrosion-Resistant Materials and Special Tests." Kirk H. Logan. *J. Research Natl. Bur. Standards*, Vol. 23, Oct. 1939, pp. 515-542. Research.

The soil-corrosion investigation begun in 1922 showed that many soils cause rapid corrosion of the commonly-used pipe materials. The manufacturers of pipe have tried to develop materials more resistant to corrosion. In 1932 some of these materials were buried in 15 corrosive soils for the purpose of determining their resistance to soil corrosion. Specimens are being removed at intervals of 2 or more years. (For observations on the first-removed group, see also *Metals and Alloys*, Vol. 9, July 1938, p. MA 449 L/2). The second group of specimens, including 41 metals and alloys and 11 protective coatings, was removed in 1937 and are the subject of this progress report.

Several of the materials resisted very well most of the soils to which they were exposed, but none of them was unattacked by all of the soils. The results indicate that pipe materials should be chosen with respect to the soils to which they are to be exposed. The addition of small amounts of Cr, Cu, Ni, and some other elements to iron or steel appears to have no marked effect on the resistance of such materials to soil corrosion. Ferrous alloys containing large amounts of Cr showed definitely lower weight-loss rates than the other ferrous materials tested. They also had fewer pits per unit area, but the alloys containing Cr alone were pitted deeply in certain soils. The addition of Ni to Cr-Fe alloys appears to improve the alloy with respect to loss of weight and depth of pits. An alloy containing 23% Cr, 13% Ni, and 1.8% Mn is less resistant to soil corrosion than an alloy containing somewhat smaller percentages of these elements. Two ferrous alloys which contained both Cu and Ni in considerable amounts resisted soil corrosion better than the other ferrous materials, with the exception of those containing large percentages of Cr.

Copper and its alloys corroded at much slower rates than the commonly-used ferrous materials at most of the test sites. The pits on many of the specimens were too shallow to be measured accurately by the methods used. Dezincification affected the specimens containing large percentages of Zn in several soils.

With one exception, all the coatings examined appeared to have reduced the intensity and amount of corrosion on the pipes to which they were applied as compared with unprotected pipe. However, many of the coatings showed definite signs of deterioration. A vitreous enamel and two thick rubber coatings afforded almost complete, if not entire protection to all the specimens to which they were applied. These materials showed no visible signs of deterioration.

WAT (3)

3a. Ferrous

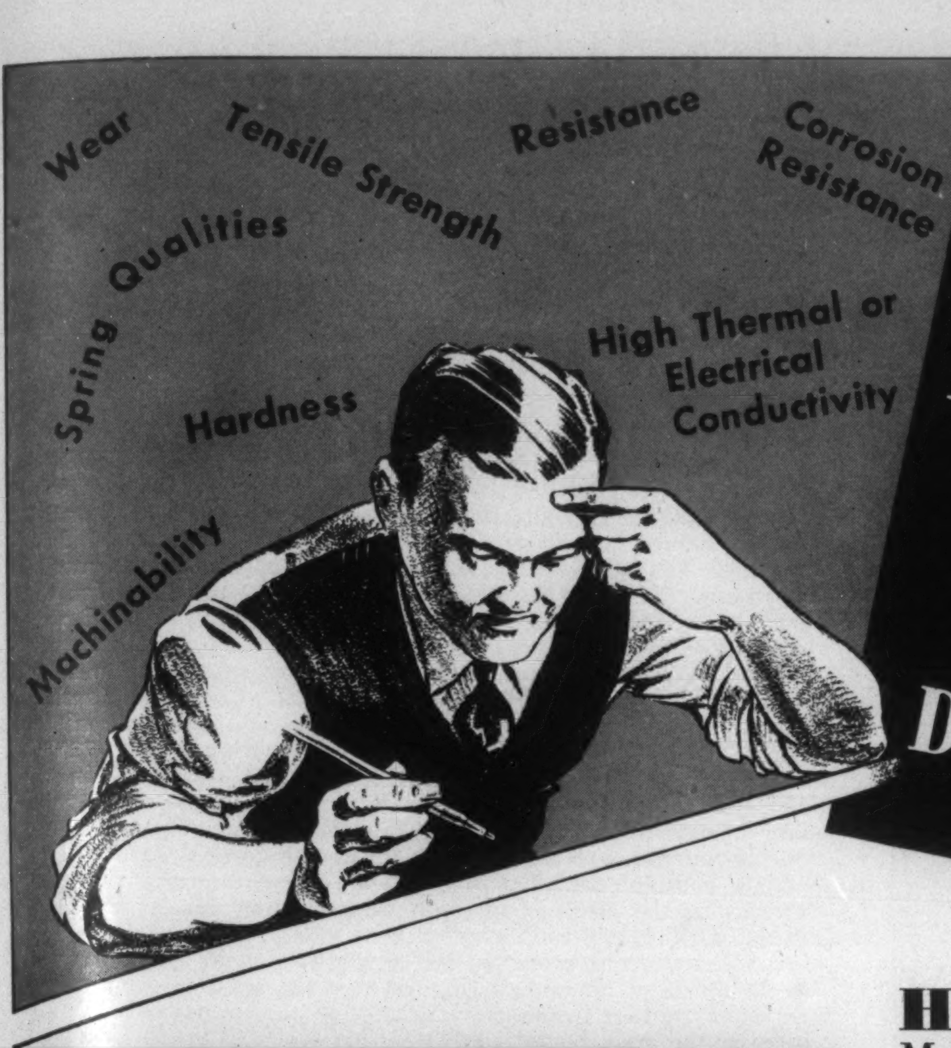
Materials and Wear of Cylinder Bores

"Bore Wear from the Viewpoint of Materials." Paul S. Lane (Am. Hammered Piston Ring Div., Koppers Co.) *S. A. E. Journal*, Vol. 45, Oct. 1939, Trans. pp. 413-420. Investigation.

Bore wear was studied from the point of view of the materials commonly used for high-speed automotive, Diesel and aircraft-engine cylinders, liners and rings. The laboratory wear-testing machine used was of the simple brake-shoe type, normally run dry. Flat-faced samples were used with a fixed load on the beam. Two "siamesed" bores cut from a 6-cylinder engine were sectioned and examined. Although hardness variation was only from 88 to 93.6 Rockwell "B," the weight loss or wear for 1 hr. running varied from 12.3 to 26.8 mg. Considerable variation in wear was found in any one section, and all sections showed highest hardness and lowest wear near the top. The best wearing area was along the line where the section thickness was greatest.

An entire 6-cylinder engine block was cast, using 3 different size cores, with 2 bores of each size, to give 3 different metal thicknesses in the casting. The block was then bored out to the usual diameter, sectioned, and examined. One of the light as-cast sections showed low hardness, high wear and a "freak" structure of superfine graphite and ferrite. Critical cooling conditions seemed to be the only cause for this section to solidify as it did. Structures of this type have poor wearing qualities. The other light as-cast section had a normal structure. Consistently regular structures in so complicated a casting as an engine block are difficult to obtain. After considerable experimentation, the engine builder was able to eliminate most of these differences, mainly through control of cooling conditions in the casting. Dynamometer and road tests indicated improved uniformity and reduction of wear with the new practice and largely confirmed the wear-test conclusions.

Piston-ring irons have a network structure with uniform graphite present in an extremely fine distribution, and for this reason are not the "best-wearing" irons. Measured on a weight-loss basis under direct comparison with other conventional iron structures, they normally give relatively high weight-loss figures. Further refining, such as by annealing, will give even higher weight-loss. The hardness drop due to annealing is slight compared to the increase in wear. Temperatures of at least 800°-1000° F. are necessary before wear rates are affected. However, piston-ring



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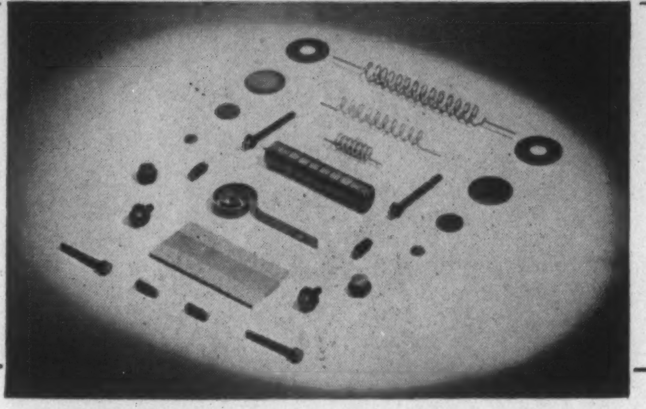

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irons do have the significant and desirable faculty of wearing away with very little tendency to accumulate wear products on their rubbing surface. In fact, this factor is probably of equal or greater importance than the actual weight loss. Gray cast iron structures may be classed as (1) those which give high weight loss, but without serious mutilation to the rubbing surfaces; and (2) those which show low weight loss, but are characterized by surface blemishing such as welding or scuffing.

The first type usually gives protection or "self sacrifice" against a wide range of mating materials, while the second often causes high wear of mating surfaces, even though these are of much higher hardness. Group 2 materials usually have much lower Brinell hardnesses. Group 1 iron is dense, fine-grained, uniform, hard and strong. Group 2 iron is open, coarse-grained, heterogeneous, relatively soft, and weak. These characteristics are shown by results of laboratory tests on Groups 1 and 2 iron run against a wide range of materials and hardness. Normally piston-ring wear is to be preferred to cylinder abuse. The results also illustrate the need for considering wear of both surfaces, and that Brinell hardness gives no direct measure of wear resistance. However, hardness values offer a more simple and readily understood identification and this warrants their use, provided it is recognized that the structure determines hardness as well as wear. There is a possibility of balancing ring and cylinder wear. While a combination of hard rings and liners will give the lowest total wear, such a combination cannot always be best applied, as other factors must be considered.

Thus, the results of tests of various steels and cast irons used for liners when run against cast iron representing conventional piston-ring structures showed that carburized S.A.E. 2512 steel gave the lowest total loss of weight, with ring-cylinder wear ratio of 7.7 and smooth surfaces on both materials. Plain cast iron compared favorably from all angles. Service experience is the main guide with regard to these materials. The structure of many of these alloys lacks both lubricating and bearing constituents, and approaches the amorphous or vitrified in nature. The very hard alloys, if used successfully in a wear application, wear so slowly that they may almost be considered as not wearing at all. Their hard surface, however, although not easily marred, lacks any "healing" properties. Once mutilation is started, it usually multiplies rapidly. These materials appear to operate with a small safety factor and demand that conditions vary not too much from a certain critical range. MS (3a)

Chromium-Manganese Stainless Steels

STUDY OF THE CORROSION RESISTING PROPERTIES OF CR-MN STEELS ("Contribution à l' Étude des Propriétés de Résistance à la Corrosion des aciers au Cr-Mn") A. I. DE SY. *Rev. Mét.,* Vol. 36, Sept. 1939, pp. 389-400. Research.

Five proposed Cr-Mn steels, of the following compositions, were examined for their corrosion-resisting properties:

No.	%C	%Cr	%Mn	%Ni	%Cu
A	0.15	14.8	10.0	2.1	..
B	0.12	16.1	10.1	2.1	..
C	0.08	18.3	9.0	..	0.8
D	0.10	14.1	8.8	1.5	0.3
E	0.12	15.2	11.8	2.1	0.5

Susceptibility to intergranular corrosion was tested by exposure to 10% HNO_3 + 4% HF at 70°C. and to boiling 10% H_2SO_4 + 10% $CuSO_4$. Steels A, B, and C were tested in the first solution, but the general attack was so great that samples of A and B in the natural condition were completely dissolved in 70 hrs.; therefore this solution was not suitable for studying intergranular corrosion. Tests in H_2SO_4-$CuSO_4$ were more satisfactory for this purpose. After 1 hr. exposure at 725°C., A, B, D, and E were susceptible to intergranular corrosion. Steel C showed only general attack after the same treatment, but was susceptible to intergranular attack after 1 hr at 600° or 650°C. Cold work (such as cold-shearing) seemed to increase the corrosion resistance of the steels. The rate of attack of steel E after holding 1 hr. at 725°C. was great enough that the amount of metal dissolved in the H_2SO_4-$CuSO_4$ could be analyzed. The % Cr in the metal going into solution increased from 7.48% during the 1st hr. to 14.50% during the 12th to 24th hrs.; the % Si in the dissolving metal remained constant, and that of Mn was somewhat greater than that present in the steel. Only one determination for Ni could be made, which gave a Ni content of 1.87% for the 12th to 24th hrs. These results prove the selective action of the reagent as well as the decreased amount of Cr present in the grain boundaries as a result of the heat treatment, which led to the formation of Cr carbides at the grain boundaries.

None of the steels had a corrosion resistance equal to 18% Cr/8% Ni. After 100 hrs. of alternate immersion in 2% NaCl, all Cr-Mn steels showed rust spots. The mixed austenitic-ferritic structure could be revealed either by the usual electrolytic oxalic acid etch, or by an electrolytic etch in 10-15% chromic acid with a current density of about 20 amp./dm.^{2} JZB (3a)

Steel Standardization in Machine Tool Plants

"STEEL STANDARDIZATION." A. L. HARTLEY (R. K. Le Blond Machine Tool Co.) *Iron Age,* Vol. 144, Sept. 7, 1939, pp. 27-33; Sept. 14, 1939, pp. 61-66; Sept. 21, 1939, pp. 46-48, 81; Oct. 5, 1939, pp. 31-33, 65-66; Oct. 12, 1939, pp. 33-37. Comprehensive survey.

The purpose of standardization in any shop is basically to improve products and at the same time to reduce net costs. It is always desirable to select about 5 grades of special-purpose steels for special parts. This program will reduce the total number of types of heat treatment cycles required. An efficient standardization program must be considered from several viewpoints, namely: (1) General types of steel required for parts fabricated from bar stock and forgings; (2) analysis of physical and metallurgical requirements of each of the various types; (3) analysis of the relative merits and net costs of various types of bar stock finishes; and (4) establishment of purchasing specifications, material inspection program and code system for each of various grades of steel and for each heat treatment.

To clarify, some of the problems, a hypothetical program is taken up. A manufacturer of mechanical equipment such as machine tools, etc., generally requires the following types of steel: *Class I*—general application steels (stock materials), which would include (a) screw stock, (b) low-C or low-C-Mn carburizing steel, (c) medium-C or medium-C-Mn steel, (d) alloy oil-hardening steel, (e) alloy carburizing steel; (f) high-C tool steel. *Class II*—special application steels, such as (a) alloy oil-hardening steel with higher alloy content than (d) in Class I above, (b) non-deforming oil-hardening tool steel, (c) shock-resisting alloy tool steel, (d) abrasion-resisting alloy tool steel, and (e) high-speed tool steel, say of the 18-4-2 + Mo type.

A brief resumé of the effect of alloying elements such as C, Mn, P, S, Si, Ni, Cr, Mo, V, W and Co is given. In an extensive table the analysis, cold-drawn core and case properties, base price plus alloy extra, and availability as a stock item in complete size ranges for carburizing steels, are presented. In another table the analysis and physical properties of (1) fine-grain steel heat-treated to a lamellar structure, (2) fine-grain steel hardened and tempered at 400° F., and (3) fine grain steel treated to maximum hardness within the practical machining range, are given, together with the as-quenched, surface hardness of fine-grain steel, the as-quenched core hardness of fine-grain steel, and the base price plus alloy extra. The 2nd instalment tabulates and describes non-deforming, abrasion-resisting and shock-resisting tool steels, and gives their chemical compositions, trade-names, various physical properties, and price/lb.

In the selection of carburizing steels by machine tool plants the screw-stock may be eliminated. As to C-Mn and low-C steels, S.A.E.X-1314 has suitable properties required in this type of steel. A medium-C steel finds considerable use in all plants for such parts as lead screws, cross feed screws, elevating screws, etc. A good steel for this type of material would be S.A.E.X-1335. Alloy oil-hardening steel for machine tools should have sufficient alloy content to insure uniform physical properties when used for heat-treated parts having heavy sections. The steel selected should be thoroughly tested. Fine-grain S.A.E. 4145 (Cr-Mo) has many desired qualities including good flame-hardening properties. Fine-grain S.A.E. 3140 (Ni-Cr) may be considered if the hardness range above 302 Brinell is not a vital factor. If maximum fatigue resistance is required S.A.E. 4640 (Ni-Mo) is recommended. Alloy carburizing steels for general purpose applications have higher physical properties and simple heat treating cycles. They are essential for parts requiring wear resistant case and tough, ductile core. Fine-grain S.A.E. 4615 has many of the qualities required. All machine tool plants require a selected grade of high-C tool steel. A grade having 1.00-1.15% C, 0.025% maximum S, and hardenability that will result in medium penetration of hardness is suitable for most applications.

Alloy oil-hardening steels for heavy sections should have good machinability at high hardness and high hardenability; a steel that might be recommended is S.A.E. 4340 (Ni-Cr-Mo). An outline is given in the 4th instalment of properties that should definitely be specified, and typical purchasing specifications. The following items should always be specified or controlled, if good uniformity is to be maintained: Analysis, grain size, grain structure, heat treatment, hardness as-received, hardenability, surface decarburization (cold-drawn stock), surface finish, size tolerance, and straightness. The final instalment suggests a material inspection program and code system for indicating various grades of steel and heat treatments on records and drawings. VSP (3a)

Effect of Phosphorus in Cast Iron

INFLUENCE OF PHOSPHORUS ON THE PROPERTIES OF PEARLITIC CAST IRON ("Einfluss von Phosphor auf die Eigenschaften von perlitischem Gusseisen") A. THUM & O. PETRI. *Arch. Eisenhüttenw.*, Vol. 13, Sept. 1939, pp. 149-153. Research.

Twenty pearlitic cast irons of the ordinary range of tensile strengths were prepared for testing the impact resistance, and the effect of increasing P content was determined. A typical analysis is 3% C, 2.0% Si, 0.5% Mn, 0.4% P, 0.05% S. Tensile and bending strength as well as deflection increased with increasing P content up to 0.4% P; with higher P these values dropped, but the hardness kept increasing linearly with the P. In impact tests (bending unnotched bars) the energy absorbed increased to a maximum at 0.35% P and then declined fairly rapidly. Thus, the amounts of P usually present in pearlitic iron tend to give about the most favorable properties. SE (3a)

3b. Non-Ferrous

Tarnish on Silver and Copper Alloys

"THE ELECTROMETRIC ESTIMATION OF THE TARNISH PRODUCTS ON SILVER AND COPPER ALLOYS" L. E. PRICE & G. J. THOMAS. *Trans. Electrochem. Soc.*, Vol. 76, 1939; Preprint No. 11, 12 pp. Original research.

The measurement of the amount of tarnish on silver, copper, or their alloys is difficult. Gravimetric and optical methods have been used, but are not wholly satisfactory. The electrometric method consisted in making the tarnished metal the cathode in an electrolyte of 0.2 *M.* NH$_4$Cl, at a current density of about 5×10^{-4} amp./cm.^{2} Time-potential curves were obtained. The various kinds of corrosion products on the tarnished metal were identified by the potential of the cathode. These potentials, measured against a saturated calomel cell, were as follows: AgCl, —1.05 v.; Cu$_2$O, —0.37 v.; Ag$_2$S, —0.71 v.; Cu$_2$S, —1.05 v. The quantity of corrosion products was determined by the length of time the potential remained constant at the value characteristic for the corrosion product. The electrometric method agreed well with the estimation of tarnish products by weighing.

By means of the electrometric method it was shown that in a kitchen atmosphere, a Ag alloy containing 7% Zn and 0.5% Be tarnished more rapidly than pure Ag, while a Ag alloy containing 5.5% Zn, 1% Be, and 1% Ni, did not tarnish appreciably. The tarnish of a Ag-Cu alloy containing 28.5% Cu contained only Cu compounds. An alloy containing 7.5% Cu gave a tarnish containing both Cu and Ag sulphides, Cu$_2$O, and AgSO$_4$. AB (3b)

Ti
and its effect on the primary crystallization of steel

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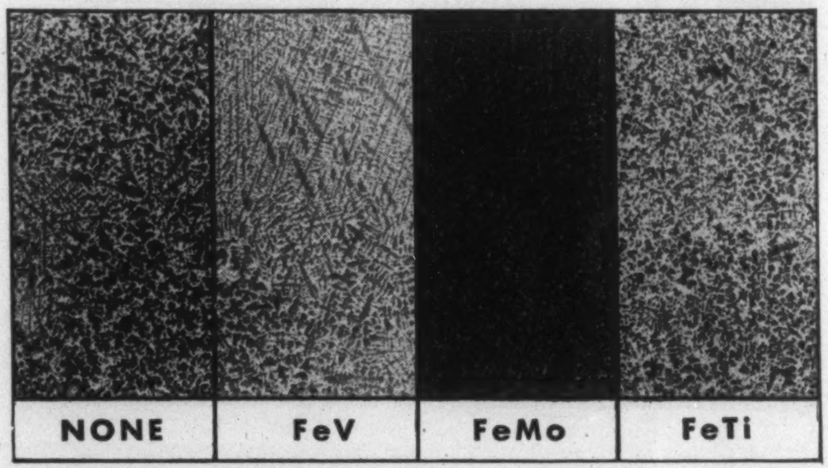

The macrographs above [from a report of the Research Inst. of the Skoda Works, Pilsen, presented as an exchange paper from the Czech. Tech. Foundry Ass'n, Sept. 1935] show the effects of different alloy additions on test ingots of .40 carbon steel made under identical conditions.

Of principal interest is the varying character of the dendritic crystals and the fact that each steel shows a well developed dendritic structure, except for the one treated with Ti where the dendrites are short, mostly nodules. This is the result of the influence of Titanium on primary crystallization which alters the mode of solidification, producing a larger number of centers of crystallization and a finer grain throughout the ingot.

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Modern Zinc Alloys

Progress in Zinc Alloys since 1900 ("Die Entwicklung der Zinklegierungen seit 1900") A. Burkhardt. *Giesserei*, Vol. 26, Sept. 22, 1939, pp. 484-487; Oct. 6, 1939, pp. 505-508. Review.

Until 1914, the only significant use for Zn alloys was for metalcraft castings. Although during the war attempts were made to use them in place of other alloys, the poor mechanical properties of the alloys then available precluded successful application. The chief difficulty seemed to be the formation of coarse grains during service, evidently caused by recrystallization taking place even at room temperature. Thus, zinc wires used as electric conductors formed crystals sometimes 50 mm. long that broke under the least mechanical strain. Research [largely in America] has since developed very high-grade Zn alloys, especially with Al or Cu as the principal alloying elements. Zinc-aluminum alloys are mainly used for die-castings, as Al added to Zn suppresses in the latter the tendency to dissolve iron. The lowest amount, for practical purposes, is 0.5% Al.

Three groups of Al-containing Zn alloys have been standardized in Germany. The first contains Zn alloys with 4-5% Al and 2.5% Cu, sometimes also up to 0.1% Mg. The lower the Pb and Cd impurities in Zn the lower can be the Mg; and the higher the Cu content, the lower must be the Mg. The second group contains 0.9-1.2% Cu, and the third lies between the other two, and comprises those Zn-Al alloys with little or no Cu. The alloys in the third group are less hard but do not age so much as the others because of the absence of Cu precipitation. An addition of 0.03-0.04% Mg of course should be made to suppress the tendency to intercrystalline corrosion in the Zn-Al alloys. The alloys of the first group and also alloys with up to 15% Al are now available in wrought form.

The following table gives the alloys must used at present for wrought products and a comparison of their mechanical properties with each other and with brass. As yet, however, there is no Zn alloy with the "all-round" good qualities of brass.

	Zinc Alloys			Brass
	Cu—poor	Cu—rich	Al—rich	
Composition %	95.5 Zn, 4 Al, 0.5 Cu, 0.03 Mg	94.8 Zn, 4 Al, 1.2 Cu, 0.03 Mg	88 Zn, 10 Al, 2 Cu, 0.03 Mg	58 Cu, 40 Zn, 2 Pb
Elastic limit (0.2%), lbs./in.^{2}	47-55,500	51-57,000	43-48,000	40-57,000
Tensile strength, lbs./in.^{2}	53-60,000	54-60,000	57-70,000	63-77,000
Elongation in 10 in., %	12-8	10-8	14-6	25-10
Reduction of area, %	55-45	40-30	60-45	30-20
Brinell hardness.....	90-105	95-110	100-120	120-140
Impact bending strength, cm.-kg./mm.^{2}	30	18-23	14-16	8-10
Notch-toughness, cm.-kg./mm.^{2}	1.5-2	1.5-2	1.5-2	2-3

The table below gives information of practical value on Zn-base alloys in all forms—sand-cast, die-cast, pressed, drawn, etc.

An impact-bending test at temperatures down to —40°C. was made with the first 5 alloys in the second table, and all showed only about 1-2 cm.-kg./mm.^{2}, except the 5th (15% Al) which had a value of 22 cm.-kg./mm.^{2} and stayed practically constant up to +20°. The others regained their impact strength more or less quickly, with rising temperature, especially the 2nd (4% Al, 1% Cu) which had recovered to 30 cm.-kg./mm.^{2} at —12°C. while the other alloys (except the 5th, of course) reached this value between 0 and 10°C.

Ha (3b)

Composition, %	Metal-form	Mechanical Properties				Main Field of Application
		Tensile Strength, lbs./in.^{2}	Elongation, %	Brinell Hardness	Impact Strength, cm.-kg./mm.^{2}	
4 Al, 3 Cu, 0.03 Mg, Bal. Zn	Die castings	41,000-50,000	2-7	90-110	5-8	Die castings of highest strength
4 Al, 1 Cu, 0.03 Mg, Bal. Zn	Sand castings	26,000-34,000	0.5-1.5	70-90	2-6	Mold castings of high strength
	Chill mold	31,000-56,000	1-7	80-100	5-7	
	Die castings	38,000-45,000	2-6	80-100	6-11	Die castings of medium strength
	Pressed	51,000-57,000	4-6	85-95	18-23	Material for pressing profiles, shapes, tubes, etc., but not screw-machine parts
	Drawn	54,000-60,000	8-10	95-110	18	
4 Al, 0 or 0.5 Cu, 0.04 Mg, Bal. Zn	Die castings	36,000-43,000	2-6	60-90	7-12	For absolute dimensional accuracy
	Pressed	53,000-60,000	8-12	90-105	>30	Profiles, hot-pressed parts, tubes, but not screw-machine parts
	Drawn	54,000-60,000	8-12	90-105	>30	
10 Al, 2 Cu, 0.03 Mg, Bal. Zn	Drawn	57,000-71,000	6-14	100-120	>30	Pressed and drawn material for a variety of purposes
	Age-hardened	65,000-92,000	6-12	130-170	8-15	
15 Al, 0.05 Mg, Bal. Zn	Pressed	63.000-68,000	5-8	105-115	20-25	Tough pressing alloy
4 Cu, 0.2 Al, Bal. Zn	Sand cast	15,000-25,000	0.5-1.5	75-85	0.5-0.7	Where dimensional accuracy in wrought and cast materials is important
	Chill mold	24,000-27,000	2-2.5	85-90	0.7-1.1	
	Pressed	43,000-51,000	25-40	80-90	25-30	
4 Cu, 0.3 Bi, 0.3 Mn, 0-0.3 Al, Bal. Zn	Drawn	44,000-51,000	10-25	75-90	8-15	For screw-machine parts

High-Temperature Properties of Zinc Alloys

Physical Properties of Some Zinc Alloys at Elevated Temperatures ("Mechanische Eigenschaften einiger Zinklegierungen bei höheren Temperaturen") Kurt Bayer & Wolf Wolf. *Z. Metallkunde*, Vol. 31, Aug. 1939, pp. 267-269. Original research.

The tensile strength, hardness, elongation and reduction of area at temperatures up to 350° C. were determined on cast and extruded rods of 5 different Zn alloys containing 0-15% Al, 0-4% Cu, 0.05% Mg and 0-0.3% Bi. The testing results are graphically presented. All alloys show a drastic loss of hardness and a less-pronounced decrease of tensile strength with rising temperatures, while elongation and reduction of area gain correspondingly. Two alloys, containing 4% Al, 1% Cu, 0.03% Mg, in one case and 4% Cu and 0.2% Al in the other, maintain their room temperature strength up to about 150° C. Tests were made on sand cast samples. Three extrusion alloys varying widely in composition show hardly any differences in their loss of strength and hardness with rising testing temperatures, although the Al-bearing alloys become more ductile with rising temperatures than the Zn alloys containing Cu as the main alloy constituent. Applications of Zn alloys at elevated temperatures should be made only with the utmost precaution, owing to their low creep strengths. EF (3b)

Corrosion Resistance of Magnesium Alloys

CORROSION PROTECTION OF MAGNESIUM AND ITS ALLOYS ("Ueber den Korrosionsschutz von Magnesium und seinen Legierungen") B. WULLHORST. *Mitt. Forsch-Inst. Edelmetalle,* Aug. 1939, pp. 16-25. Review.

The protection of magnesium from corrosion by alloying with other metals can be obtained with only a limited number of alloying constituents—generally speaking, only those in the neighborhood of Mg in the electromotive series. Silver, Cu and Ni are usually not used as their solubility in Mg is only slight and the excess of undissolved metal remaining leads to corrosion; they are used only for alloys exposed to non-corroding environments.

The most important alloying metals with magnesium are Al, Mn, Zn, Si and, most recently, Ca. Al and Zn increase the mechanical strength, Si and Mn produce fine grain, and Mn and Ca are particularly beneficial to corrosion resistance. Additions of Pb (0.5-22%) or of 1-10% Cd to Mg alloys with subsequent aging at 175° C. is said to produce high corrosion resistance (American patents 2,124,537 and 2,124,571), as are also 0.05% Sb or Bi to Mg-Al and Mg-Zn alloys. Beryllium is said to effect an extraordinary increase of corrosion resistance even in amounts as low as 0.005-0.5%; the upper limit is the solubility limit of Be in Mg. Beryllium coarsens the grain, but this condition can be counteracted by the addition of Ti or Zr, the latter in amounts of 0.005-0.5%.

The elements of the alkaline earth group have also been proposed as corrosion-retarding addition agents. Barium is used in alloys for better material in electron tubes. Calcium increases the corrosion resistance of Mg considerably; an alloy with 1% Ca is particularly resistant to moist air. Magnesium with 3% Li shows a considerable increase in strength and corrosion resistance over pure magnesium. A British patent (489,320) proposes Mg alloys with 1-5% K or Na for corrosion resistance.

Protection of magnesium by coatings of fluorides, phosphates, silicates and chromates are widely used now, especially the chromate and phosphate coatings; methods for their production are described. Electrolytic production of protective films, similar to the anodic oxidation of aluminum, have had only limited success. Good adhesion is difficult to obtain and requires very careful pretreatment of the metal. Ha (3b)

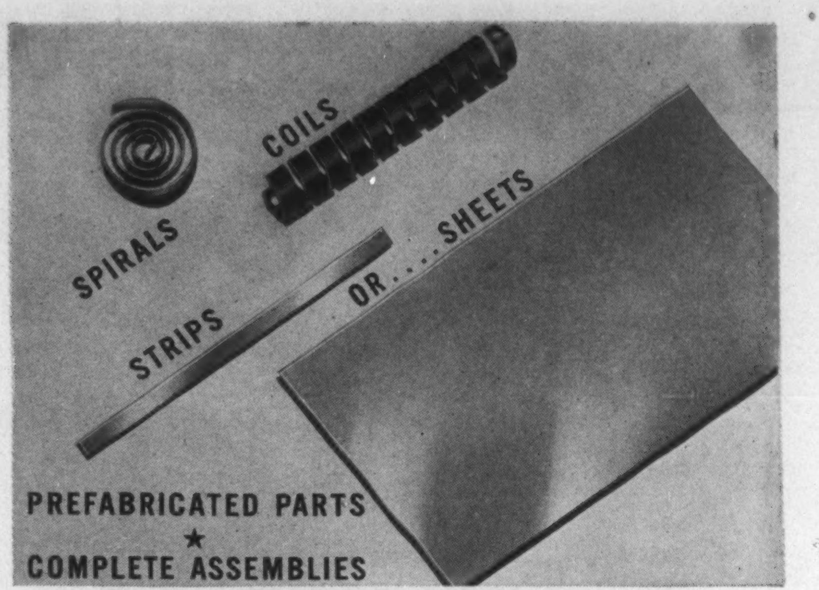
Light Metal Bearings

EXPERIMENTS WITH LIGHT METAL BEARINGS IN TESTING MACHINES AND AIRPLANE ENGINES ("Versuche mit Leichmetallagern in Prüfmaschinen und Flugmotoren") A. BUSKE. *Automobiltech. Z.,* Vol. 42, July 1939, pp. 355-363. Original research.

The behavior of light metals as bearing materials was tested by a simple heating and cooling test using an oil bath for heating; by engine tests as connecting rod bearings, as secondary shaft bearings and as gear drive bearings, and tests in special bearing testing apparatus. The effect of permanent deformation in light alloy bushings in steel housings due to difference in expansion and shrinkage is recorded. Practical difficulties that can result from this can be overcome by using housing ends of thin wall thickness or light alloy housings. Some light alloys failed quickly as connecting rod bearings, others stood up for considerable periods and are expected to perform satisfactorily in practical application. Cam shaft and other secondary bearings exert less severe stresses on bearings. Light metals were in most cases satisfactory. For gear bushings light metal may be used if, in case of severe stresses, special design is applied.

The bearing testing machine consists of a bearing loaded by means of a spring permitting a load of 20 tons. Thus a surface load up to 11,000 lb./in.^{2} could be applied. The results supported those found by the heating and engine tests. Materials of relatively low hardness but good ductility showed relatively good resistance to edge pressures. Materials of otherwise similar characteristics show different behavior as to seizing or "wetting" of the shafts. Generally hardened shafts (60 Rockwell C) are recommended. The recommended principles for bearing design are tested by oil-pressure measurements over the length of the bearings. [Unfortunately the analyses of the light alloys tested are not revealed; this reduces the value of this otherwise very interesting paper. The testing methods applied and some conclusions may be valuable as the call for the development of light metal bearings, especially for automotive and aircraft engines, has recently increased considerably in this country.—R.P.S.]

RPS (3b)



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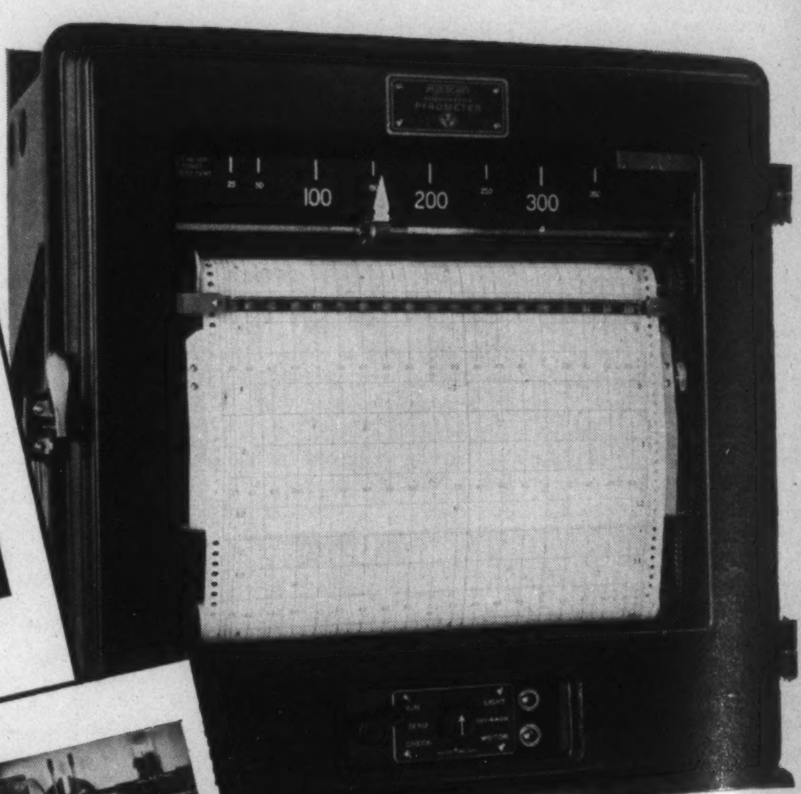

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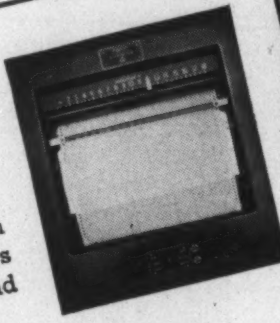

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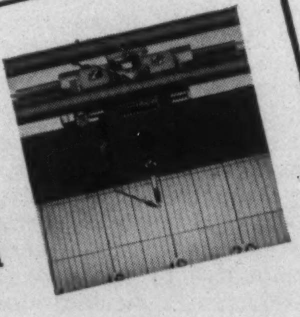

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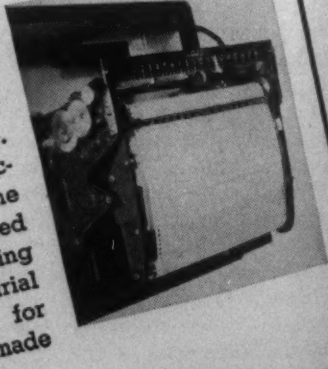

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4 Testing and Control

METHODS, EQUIPMENT

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Thickness of Electroplates

A Composite

The applicability of dropping tests, as compared with microscopic and magnetic methods, for measuring the thickness of zinc and cadmium coatings on steel has recently been investigated by Brenner (see *Metals and Alloys,* Vol. 10, Dec. 1939, p. MA 718 L 5), who found the dropping tests generally useful, the microscopic test in general, satisfactory only in laboratories experienced with it, and the magnetic method "promising."

Preference for the dropping tests over the microscopic for cadmium and zinc coatings is also expressed by J. W. Higgins of Packard Motor Car Co. ("Microscopic and Drop Test Methods on Metallic Electrodeposits," *Bull. Am. Soc. Testing Materials,* Oct. 1939, pp. 21-24), because of the tendency of cadmium and zinc to smear in metallographic polishing. However, the microscopic method offers several distinct advantages for harder deposits, particularly copper, nickel and chromium; it is rapid, the minimum plate can be determined, and a deposit that is not properly adherent will leave the base metal during the preparation of the sample. On the other hand, chromium deposits are often determined by drop test, owing to the difficulty of measuring their extreme thinness under the microscope. Detailed directions are given for both tests.

Additional highly useful data on the application of Clarke's modification of the dropping test for chromium deposits are given by M. M. Beckwith of J. B. Ford Sales Co. ("Determination of Thickness of Electrodeposited Chromium," *Monthly Rev. Am. Electroplaters' Soc.,* Vol. 26, Oct. 1939, pp. 769-775). This test consists in placing a drop of a reagent composed of 20 g. of Sb_2O_3 dissolved in 1 liter of HCl (sp. gr. 1.16) on the chromium-plated surface, and noting with a stop watch the number of seconds required for the chromium to dissolve, as indicated by the beginning and cessation of gas evolution. Antimony deposits during the test and is said to render the endpoint sharper. Graphs are given for converting the number of seconds to coating thickness. The rate of solution of chromium increases with the temperature. At 75°-80° F. each second is equivalent to 0.000,001 in. of chromium. X (4)

A Test for Corrosiveness of Engine-Oils

"Underwood Oxidation Test and Its Correlation with Service." H. C. Mougey (General Motors Corp.) *Bull. Am. Soc. Testing Materials,* Oct. 1939, p. 25.

The Underwood oxidation test was first developed to predict the tendency of oils, as the result of oxidation in an engine, to develop acids which would cause corrosion of alloy bearings such as those of the copper-lead or cadmium-base types. In this test oil is maintained at 325° F. in a metal container and circulated by means of an oil pump, spraying the oil against the bearings under test. Whether the bearings corrode under these conditions is taken as an indication of the likelihood of corrosion of the bearings by the oil under severe operating conditions. This test was later expanded to include a study of the chemical and physical changes that take place in an oil under these test conditions. Data are given to show the effects of operating conditions, especially temperature, and the effects of catalysts and inhibitors. The performance of certain oils in engines, and in the Underwood oxidation test is compared.

The conclusions are drawn that by means of this test it is possible: (1) To test an oil to determine whether it will oxidize, and, if it does oxidize, what products, such as acid, sludge, etc., will be formed and in what amounts. (2) To determine the amount of inhibitor in an oil, by adding measured amounts of a catalyst, and find out how much catalyst is necessary to neutralize the inhibitor in the oil. This determination of the amount of inhibitor in the oil measures the total amount of inhibitor present, but it does not distinguish between inhibitor derived from the crude oil and inhibitor added to the oil. (3) To determine the oxidation characteristics of the oil without inhibitor, by adding enough catalyst to counteract the effect of the inhibitor in the oil and then oxidizing the oil. This test indicates the character and amount of oxidation products which may be expected when the oil is oxidized in the engine under conditions where the inhibitor is not effective—for example, on the cylinder walls or in the combustion chamber.

From all these data it is apparent that high crankcase oil stability, as measured by this test, is definitely related to good actual service performance in engines with high crankcase oil temperature, or in those in which the undersides of the pistons are sufficiently hot so that the effect on the oil is the same as if the crankcase oil temperature were high. However, for low crankcase oil temperature operation, or its equivalent, other properties may be the deciding factor. VVK (4)

Impact Tests of Steels for Welding

"Notch-Bar Test Behavior of Some Welding Steels" C. E. Jackson & E. A. Rominski (Naval Res. Lab.) *Welding J., N. Y.,* Vol. 18, Sept. 1939, Supplement pp. 312-318. Research.

Report of original research. The investigation covers 23 hot-rolled laboratory and commercial steels of the plain carbon and low-alloy types. The particular aim of the study was to determine the notched-bar behavior of the overheated area, with its grain growth, backed up by heat-treated and parent metal such as is obtained adjacent to a bead weld. Single-bead welds were deposited transverse to the direction of rolling on plates in the as-rolled condition. Standard width (0.394 in.) and double width (0.788 in.) notched-bar bead weld specimens were prepared transverse to the bead weld and also from the plate material. After the bead weld sections were ground and etched the apex of the standard V-notch was machined tangent to the fusion line. One-half width (0.197 in.) specimens were also prepared from the plate material.

The use of a single width Charpy V-notched test specimen of a welding steel in the as-rolled condition may be used to indicate the degree of notch-sensitivity. The use of a single- and double-width Charpy V-notched test specimen of a welding steel with the apex of the notch tangent to the heat-affected zone under a bead weld may be used to indicate the degree of notch-sensitivity after being subjected to a weld thermal cycle. By comparing the notched-bar of plate material with that of the bead weld notched-bar, an indication is obtained of the effect of weld heat treatment on the notch-sensitivity. The use of the $\frac{1}{2}$-width Charpy notched-bar test presents useful results under only one condition and the data are in no way complete. Also inherent in this small-size of specimen is a lowering of the temperature at which the steep low-temperature drop of the total-work curve occurs; hence, ductile breaks and erratic conclusions are possible.

The use of bead weld notched-bar specimens takes into consideration the effect of the annealed zone in those steels that have a brittle annealed zone as well as those steels that have a brittle fusion zone backed up by a less brittle annealed zone. Welding technique may be varied in the preparation of the bead weld specimen in order to determine the critical rate of cooling below which the thermal cycle may produce erratic behavior. Welding technique and conditions, that is, preheat, post heat, plate thickness and welding process, may be varied in preparation of the bead weld notched-bar to suit commercial practice used in any particular welding shop. Standard conditions should be set up for comparison purposes. Some steels will improve decidedly under special welding technique. CEJ (4)

High-Temperature Testing of Steel

"Steels for High-Temperature Service and their Testing." A. E. White (Univ. Mich.) *Bull. Am. Soc. Testing Materials,* Oct. 1939, pp. 15-20. Survey.

The testing of steels for high temperature service, including short-time high-temperature tests, tensile-creep, stress-rupture, and surface-stability tests, is discussed. Charts illustrative of the type of results to be obtained are given. In the discussion R. M. Van Duzer, Jr. (Detroit Edison Co.) reported the results of some comparative laboratory and service tests in a superheater unit exposed to 925° and 1100° F. steam. The service tests agreed with the laboratory tests with the exception of a C-Mo alloy steel.

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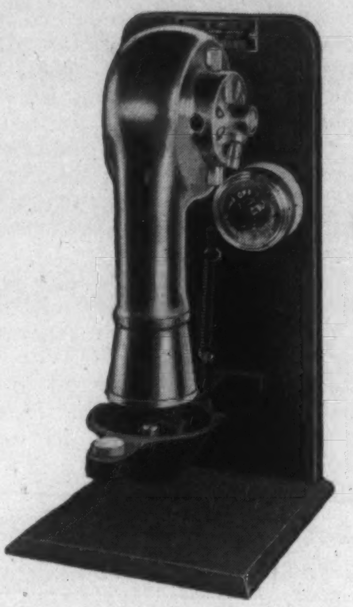

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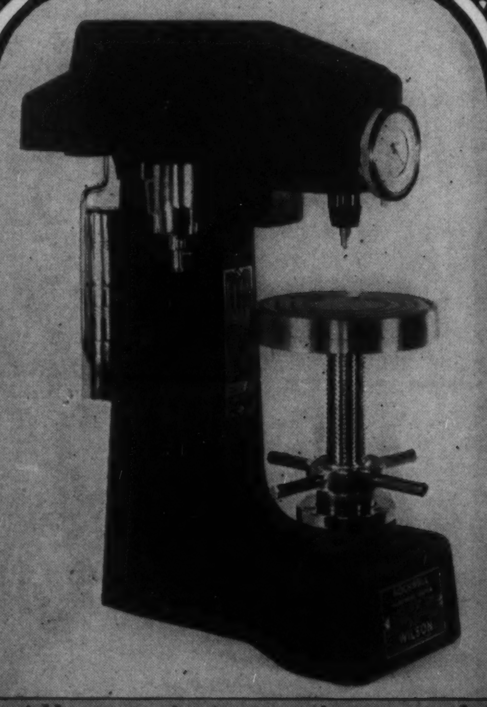

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The results of a test of 18 low- and high alloy steels in steam at 1100° F. show that the presence of any alloying element even in fairly small amounts reduces the amount of scaling and that the initial scale deposit materially inhibits subsequent attack, except in the case of the straight carbon steel. VVK (4)

Sensitivity in Radiographic Inspection

"SOME ASPECTS OF RADIOGRAPHIC SENSITIVITY IN TESTING WITH X-RAYS." H. H. LESTER (Watertown Arsenal) *Bull. Am. Soc. Testing Materials,* Oct. 1939, pp. 33-40. Research.

Experimental data are presented regarding focal distances to be used for good definition on some commercial X-ray tubes. It is shown that for best results, d/t ratios should in some cases be as high as 20. However, for practical usage where the maximum definition is not required, lower values are good enough. The effects of secondary radiation are discussed and it is shown that the lack of definition in the image is due to underexposure forced by the presence of the secondary.

Crack sensitivity was found to be 6% for two cases investigated. It is shown that detectability depends upon the area of the image as an important factor. The treatment of radiographic images as inverse shadows is shown to be inadequate since it neglects the very important third dimension. Penetrameters are discussed. They are regarded as unsatisfactory as sensitivity gages but quite important as devices for determining the correctness of radiographic procedure. VVK (4)

X-ray Examination During Fatigue Stressing

MEASURING THE STRESSES IN FATIGUE TESTING WITH THE X-RAY ("Röntgenographische Spannungsmessung bei dynamischer Beanspruchung") R. GLOCKER, G. KEMNITZ & A. SCHAAL. *Arch. Eisenhüttenw.,* Vol. 13, Aug. 1939, pp. 89-92. Descriptive.

An apparatus is described in which, by means of a rotating screen, it is possible to get X-ray diffraction patterns of a fatigue specimen while it is being alternately stressed. The diffraction patterns indicated the magnitude of the stresses. In the specimens tested it was not possible to detect local stress peaks before the appearance of cracks. [The last sentence seems to indicate the conclusion reached by Barrett and others that X-ray diffraction shows changes within the crystalline grain at an early stage but, so far, have not been reliable as indicators of the beginning of a destructive spreading crack.—H.F.M.] Se (4)

5 General

Articles pertinent to more than one of the previous sections.

Electrolytic Manganese—Manufacture and Possible Uses

A Composite

For some time, metallurgical engineers have been aware of the desirability of having an inexpensive supply of highly-pure manganese. As with many other metals, the use of the highly-pure product as an important constituent of alloys often results in useful and attractive alloy properties not attainable when low-purity metal is employed. Also, in the case of manganese, the development of the highly-pure product has revealed extremely interesting possibilities in alloys containing major proportions of that metal—in other words, manganese-base alloys. A method of producing 99.9+% Mn commercially has recently been announced and described, and full utilization of the process awaits a general awareness by industry generally of the potential value of the alloys thus made possible.

In 1934 the metallurgical division of the Bureau of Mines began to seek a practical solution of the problem of making industrially-useful electrolytic manganese on an economically satisfactory basis. The steps that led up to the final solution of the problem and the results of studies indicating the potential value of various high-Mn alloys are reported by R. S. DEAN, C. T. ANDERSON, C. MOSS & P. M. AMBROSE of the Bureau ("Manganese and its Alloys," *Bureau of Mines Report of Investigation,* No. 3477, Nov. 1939, 47 mimeographed pp., 32 figs., 127 references). Previous commercial and laboratory attempts to produce pure manganese by thermit reduction with Al or Si, by reduction of MnO_2 with hydrogen, by vacuum distillation, by electrolysis of molten oxide-silicate or fluoride baths, and by the finally-adopted method—electrolysis of aqueous manganese-salt solutions—are reviewed.

Early work at the Bureau by Koster and Shelton, using an electrolyte of manganese and ammonium sulphates in a diaphragm cell, succeeded in producing a continuous deposit of high-purity Mn from water solutions over 48-hr. periods, but the product was brittle and the procedure had several practical limitations. In a later process regeneration of Mn in the bath was accomplished with MnO rather than with $MnCO_3$; the MnO was obtained by reducing naturally-occurring MnO_2 with producer gas, and was then dissolved in spent electrolyte. It was found that with 200 g./l. ammonium sulphate a pH of 8.0 could be reached without precipitation of manganese hydroxide. The leach solution contained about 25 g. metallic Mn/liter. Iron was precipitated by oxidation and carried with it the As. Xanthates were found to be the best precipitants for Co and Ni. Any Zn was precipitated by sulphide. After these impurities were filtered off, the catholyte compartment was treated with 0.1 g./l. SO_2. Average cell voltage was 4.04; current efficiency, about 50%; power consumption/lb. of product, about 3.5 kw.-hrs. The product would have been extremely pure, except for a total S content of about 1/4%. This S may be removed by fire-refining with boron salts to give a product containing 0.006% S and 0.003% B, but recent improvements in the electrolysis itself have largely eliminated the S from the original deposit, so that fire-refining is unnecessary.

Commercial exploitation of the method has been undertaken by several companies here and abroad, and one plant, the Electro Manganese Corp., Knoxville, Tenn., is in production. Details of this company's operations are given by W. L. HAMMERQUIST ("Electrolytic Manganese—A New Metallurgical Raw Material," *Steel,* Vol. 105, Oct. 30, 1939, pp. 42-45). Either high- or low-grade Mn ore can be used, and the product has a purity of 99.94% Mn, or better.

The ore is fed into a continuous, electrically-heated furnace, against a counter-current stream of producer gas, heated to 600°-700° C. for 30-60 min., cooled to below 100° C., and dropped into 55-gal. drums fitted with clamped tops. Attempts to produce a magnetic FeO in the furnace simultaneously with the MnO, so that the Fe can be removed by magnetic separation prior to the leach, have not yet been successful. Therefore, low-Fe ore is being used. The reduced ore is leached in 8000-gal. batchs of spent electrolyte containing 200 g. ammonium sulphate, 24 g. sulphuric acid and a small amount of manganous sulphate per liter. The necessary amounts of ore, acid and ammonium sulphate are added to give the final leach a composition of 200 g. ammonium sulphate and 70 g. manganous sulphate per liter. The filtered solution is then pumped to the first purification tank for removal of As and Fe.

This highly-pure electrolyte is made alkaline by addition of CaO and NH_3, and air is blown in at the same time to accelerate the oxidation of Fe, which precipitates as $Fe(OH)_3$. To avoid excessive loss of Mn, the reaction is not pushed too far. Arsenic is either chemically combined or adsorbed in the precipitate of $Fe(OH)_3$, provided sufficient Fe is present. If the original Fe content is less than 0.1 g./l., Fe must be added as the metal or $FeSO_4$. The solution is allowed to stand for 3-4 hrs., filtered, and pumped through a small Pb-lined tank, where it is agitated and treated with ammonium sulphide to precipitate Co, Ni, final traces of Fe, and other heavy metals as suphides. The precipitate is allowed to stand for 6-12 hrs., after which the filtered solution is pumped to the catholyte storage tanks. As alkaline solutions of $MnSO_4$ are unstable, SO_2 is added until it reaches a concentration of 0.1 g./l. Further additions are made by bubbling SO_2 into the catholyte feed lines.

The electrolytic cells are of laminated wood, lined with a phenol plastic. Each is 96 x 28 x 43 in. and has room for 27 Pb anodes and 26 5-gal, cathode compartments. The latter are slotted to accommodate a 16-gage 36 x 18 in. stainless steel cathode. The cells are in 2 rows, between which are 2 lead pipe-lines for conducting the electrolyte to the cells. The anolyte is spent catholyte. The rate of catholyte feed is adjusted to obtain maximum stripping of Mn from solution. Stainless steel cathodes were selected because they resist corrosion at the liquid air interface. They must be clean and have a standard 3B finish. If rougher, the Mn is difficult to strip; if smoother, the deposit will peel of its own accord during plating because of internal stresses. If the deposit is porous, rough or badly treed, it is usually difficult to remove it even from smooth cathodes. The current-density is 22.5 amp./ft.^{2} and voltage is about 5 volts. When operating properly, an equilibrium is attained at which the Mn concentration and the pH of the electrolyte in the diaphragm remain constant. At present, the current efficiency at the cathode is 50-60%. Sulphuric acid (later used in leaching) and a certain amount of manganese dioxide are formed at the anode. The Mn concentration of the diaphragm overflow is the most important factor in determining the amount of MnO_2 formed. Certain Pb-alloy anodes inhibit the formation of MnO_2 effectively.

The plating cycle is about 60 hrs.; after this time there is a considerable drop in cathode efficiency. When the cathodes are removed they are dipped quickly in a solution that inhibits oxidation of Mn [the Bureau report mentions dilute sodium dichromate as being useful in this respect], washed thoroughly in running water and dried. The plates are flexed back and forth in a jig, causing the deposit to flake off in most cases. Sometimes they must be vibrated rapidly with an air hammer to remove the entire deposit. The small amount of Mn that always adheres to the cathodes is removed with HNO_3. The stainless steel cathodes then are buffed to a smooth finish, cleaned, and redipped in nitric acid to restore passivity. The manganese as now produced, contains 0.002-0.02% of Fe and S. It is believed that within a short time these impurities will be held to such low limits that only a spectroscope will detect them.

According to the Bureau's report, a high-S product is most likely caused by the formation in the circuit of thionates from SO_2 and xanthates, so that the use by Electro-Manganese Corp. of ammonium sulfide to remove the nickel, cobalt, etc., is no doubt partly responsible for the low S content of the commercial product.

The formation of manganese dioxide at the anode, particularly with lead anodes, originally presented an economic drawback to the electrolytic process. Hammerquist mentions (see above) that "certain Pb alloy anodes" effectively inhibit this formation of MnO_2. Lead-base alloys for this purpose have been specifically developed and are described by COLIN G. FINK & MORRIS KOLODNEY ("Anodes for the Electrowinning of Manganese," *Trans. Electrochem. Soc.,* Vol. 76, 1939, Preprint No. 5, 25 pp.). With plain lead anodes, about 1/4 as much Mn as is deposited is oxidized to MnO_2. Duriron anodes were also unsatisfactory, because they allowed iron to enter the bath. The ferric iron

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lowered the cathode current efficiency of Mn deposition until deposition finally ceased. A large number of alloys, mainly alloys of Pb, were tested as anodes. Of these, a Pb-Sn-Co alloy was the best. This alloy was prepared by melting Pb and Sn and adding a Sn-Co master alloy. The alloy consisted of a solid solution of Pb and Sn, containing dispersed particles of the compound CoSn. A satisfactory alloy had the composition: 1-4% Co, 50-90% Pb, and the rest Sn.

The anodes remained smooth and clean in use, only a thin black film forming on the surface. However, before using them in a Mn bath, it was necessary to preform an oxide film on these anodes by making them anodic in a dilute $(NH_4)_2SO_4$ solution. The anodic current efficiency of formation of MnO_2 was only a few tenths of a per cent. An increase in the pH of the bath decreased the formation of MnO_2 on Pb and on alloy anodes. The alloy anode does not dissolve in the bath, as no qualitative test was obtained for its constituents in a used bath. The reason that these alloy anodes do not form MnO_2 is that the Co prevents formation of PbO_2 on the anode, the PbO_2 being necessary for the formation of MnO_2. The alloys containing over 2% Co also have a lower oxygen overvoltage than Pb, which condition is unfavorable to the production of MnO_2.

The potential value to industry of electrolytic manganese as a constituent of alloys is cautiously indicated by Dean *et al* after a very complete description of several series of alloys prepared by them and comparison with the results of other workers. The electrical properties of Cu-Mn alloys made from electrolytic Mn differ greatly from those of alloys heretofore reported. Their spread of electrical resistance is very great, and indeed, encompasses resistances among the highest ever recorded for ductile alloys of fairly high melting point. Thus an alloy of 65% Mn, 35% Cu has a specific resistance of 180 microhms/Cm.^{3} Cold working produces only a very small change in the electrical resistance of these alloys. Similarly, the hardness relations for the electrolytic Mn-Cu alloys differ from those of alloys with impure Mn. In the extreme case of the 10%-Cu alloy, quenching from 900°-1000° C. and reheating to 500° C. increases the hardness from —30 Rockwell C to 48 Rockwell C, "perhaps the greatest range ever recorded for a non-ferrous alloy."

Similar data (no information on engineering properties is given, because of the small-scale of the experimental production) for alloys of Mn with other metals indicate certain groups to be practically assured of eventual industrial use. Among these are: (1) Mn-Cu alloys combining high strength with very high vibration damping capacity at low stress. (2) Hardenable stainless alloys of the Fe-Cr-Mn type, which may be especially useful for bearings and tools. (3) Alloys of the Cu-Zn-Mn and Cu-Ni-Mn series, which have many of the properties of brass and "nickel silver." (4) Alloys containing about 65% Zn, 20% Mn and 15% Cu, which give strong tough castings. (5) The alloys of Mn with Al, which appear to be far more useful when made with electrolytic Mn than when made with silicothermic Mn, for example.
X (5)

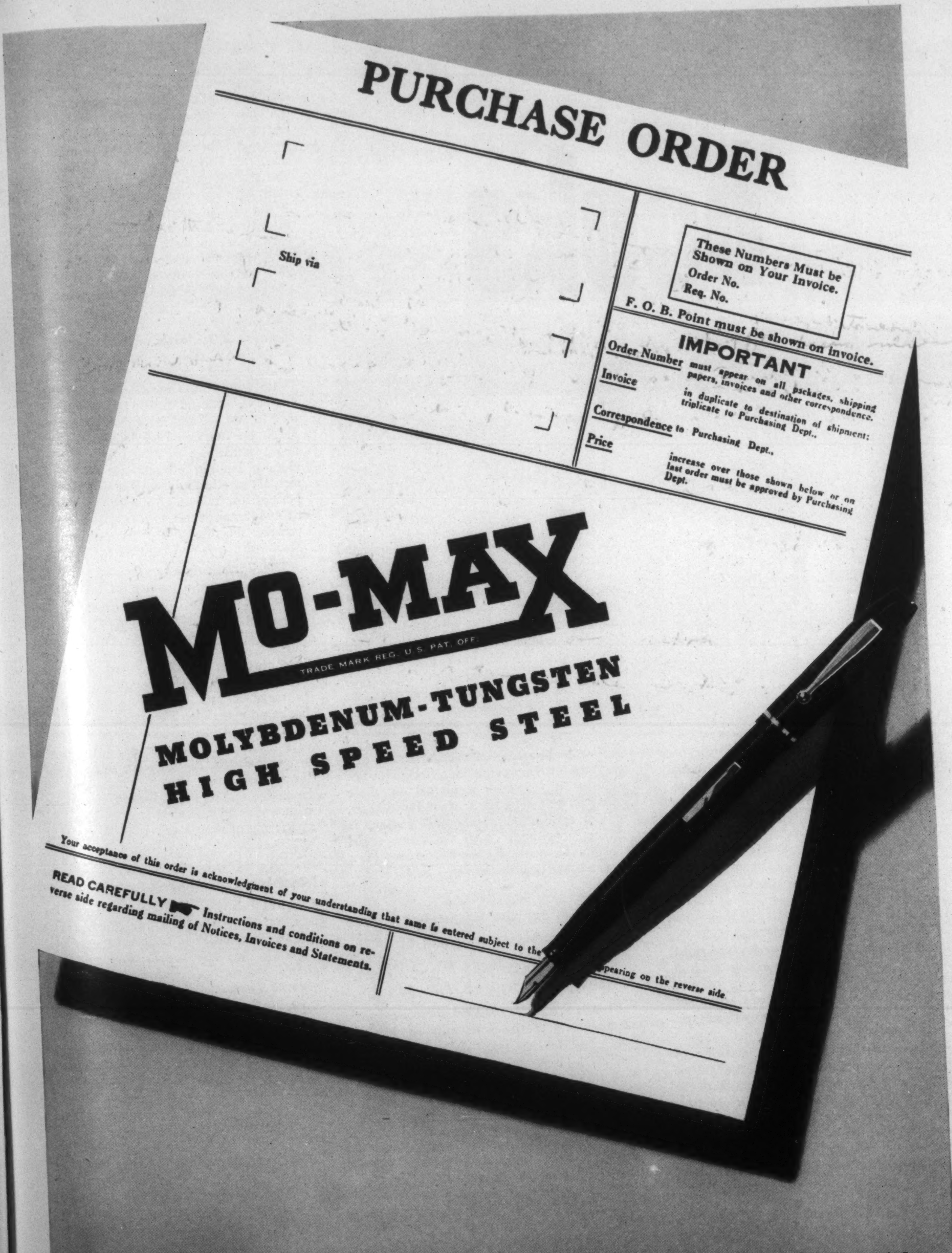
Zinc

Metallwirtschaft, Vol. 18, Aug. 25, 1939, pp. 724-750.

The above issue of *Metallwirtschaft* is devoted to a series of short articles on zinc and its alloys. "The Development of Zinc Consumption," pp. 724-726, indicates that the demand for zinc reached an all time high in 1937. The use of high-purity zinc has practically doubled since 1929. The United States is the greatest zinc consumer followed by Germany and Great Britain. "The Production of Rods and Shapes of High-Purity Zinc Alloys," pp. 726-729, discusses Zn extrusion alloys containing either Cu or Al or both. These alloys show a tendency to hot shortness and it has been found that to get maximum extrusion speed the billet, container and dies should be maintained at a low temperature. This necessarily requires that high specific pressures be used. When extruded stock is cold drawn the material becomes softer.

An article "The Machinability of Zinc Alloys," pp. 729-735, points out that by altering the tool shape and cutting speed the type of chip formed can be changed. High speeds and feeds will give short chips but will leave a roughened surface. Addition of a small amount of Bi will produce an alloy that is suitable for screw-machine stock. In an article "On the Influence of Deformation Velocity on the Strength and Drawings of Zinc Alloys," pp. 735-739, it is pointed out that the tensile properties of Zn alloys are affected by the test velocity, the more so as the amount of cold work is increased. The depth of draw is much more dependent on the drawing velocity for highly alloyed sheets than for low alloy content sheets.

Other brief articles on the drawability of Cu-containing Zn alloys, the surface protection of zinc coatings and alloys, developments in Zn-base bearing metals and the use of zinc scrap are included. See also *Metals and Alloys*, Vol. 10, Oct. 1939, p. MA 625 R/9.
GA (5)



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Notched-Bar Testing Surveyed

NOTCH IMPACT TESTING (Prüfung der Kerbschlagzähigkeit). Part C, Section 2 of *Gmelins Handbuch der anorganischen Chemie,* 8th Ed., System No. 59: Iron. *Edited by E. Francke. Published by Verlag Chemie, G.m.b.H., Berlin, 1939. Paper, 7x10¼ in., 288 pages. Price 33 RM.*

This section of the well known "Gmelin" is a comprehensive survey of the literature on notched-bar impact testing up to October, 1938. As a "correlated abstract" the task has been done exceptionally well although the only critical comments on the subject matter are those given as citations from authorities. The point of view is largely that of continental Europe, but English and American work is well represented.

The first 162 pages are devoted to the test itself, and cover the standards adopted by the various countries as well as various special tests. Generous space is then given to ferrous and non-ferrous materials and special products, such as carburized steel, rails, welds; methods of testing at high and low temperatures; the aging of steel and weld metal; tensile impact tests; and the somewhat irrelevant question of correlation with other tests.

In the final section on the meaning of the test (of about one page) the author makes the significant comment that the value of this test lies in its ability to produce the change from ductile to brittle fracture, though no attempt is made to use German, English or American literature to show how this principle is to be put into effect in practical testing. Instead, a citation is quoted to the effect that the impact value of the standard test is generally used as the criterion for judging the steel. Furthermore, the test is said to be useful to follow the effects of heat treatment, cold work, and aging, and to evaluate the ability of the material to overcome the effects of stress raisers when subjected to impacts.

This book gives an excellent summary of what has been written on the notched-bar impact test. The only adverse criticism of importance relates to certain things that were not said but which need to be said. Thus, while the array of test data presented is very imposing, it can be of only limited use to engineers and metallurgists. Presumably the mere presentation of such information fulfills the purposes of "Gmelin" but at present there is a real need of revamping our attitude toward this test and of improving our technique of utilizing it. Special emphasis on these points, as well as on the Ludwik Hypothesis, and its application to practical testing, is lacking, although such matters could properly be made the central theme of a book on notched-bar testing.—S. L. HOYT.

Materials for the Engineer

ENGINEERING MATERIALS. *By Alfred H. White. Published by McGraw-Hill Book Co., New York, 1939. Cloth, 6¼x9¼ in., 547 pages. Price $4.50.*

This is a new text book for a course for all engineers at the University of Michigan. The preface says "it is hoped that practicing engineers may also be interested in a systematic presentation of recent advances in the field of materials."

Around 200 pages are devoted to iron and steel, 65 to non-ferrous alloys, 20 to corrosion, the balance to clay products, cements, fuels and combustion, water, paints and plastics. It deals with properties rather than with methods of testing.

To attempt to give an insight into the smelting, melting, fabrication and heat-treatment of steel and analogous treatment of all the other topics in 550 pages is a difficult task, but one reasonably well accomplished. In spite of the tabloid treatment of many topics, there are, in the metallurgical portion at least, few inaccurate or misleading statements, though a few jar the reader a bit, such as the intimation that, in the melting of cast iron, graphite flakes go into solution with difficulty; and that shatter cracks in rails are due to uneven cooling. On the whole, the statements are accurate, although generally so brief that the student who reads a fact for the first time will find it much harder to grasp than if the explanation had not been made in so breathless a fashion. The book would have been easier to write and easier to read in two volumes rather than one, but probably the cost to the student of a text book played a part in the adoption of so compressed a style. Since the book is the first approach to the topics covered for all engineers at Michigan, one would have liked to see more than a page and a half on welding, more than the same on fatigue (with only a mild mention of stress-raisers and stress concentration), more than a page on "18 and 8," and more than a short paragraph on tungsten carbide tools. Precipitation hardening is hinted at under duralumin, but not brought out as a fundamental metallurgical phenomenon. Austempering, low alloy-high strength steels, controlled atmospheres, furnace brazing and powder metallurgy are left out entirely. Machinability is only casually touched upon.

The "practicing engineer" will not find in it all "recent advances in the field of materials," nor will many of them be satisfied with the relative emphasis placed on those that are mentioned. But its main purpose, that of giving the student beginner in engineering a bird's-eye view of the field of materials, is nearly enough accomplished to make it rate well up among general books on materials. The course would have to be supplemented by more advanced courses in metallurgy in order to give a proper grasp of his materials to the metallurgical engineer. But his future task will be easier if the other brands of engineer with whom he must deal later have had this smattering of metallurgy.—H. W. GILLETT.

Machining Copper Alloys

THE MACHINING OF COPPER AND ITS ALLOYS. *Published by the Copper Development Association, London, 1939. Cloth, 6¼ x 8¼ in., 108 pages. Free to "those giving evidence of responsible status or genuine interest."*

Machinability depends largely on the type of chip formed, which, in turn, is primarily dependent on the structure of the alloy. With lathes and other machines rigid enough to stand the loads of extreme cutting speeds and feeds, carbide tools often justify their choice over high speed steel for copper-base alloys. Tool design is largely a matter of getting the chips out of the way.

What sacrifices of mechanical or electrical properties are involved in adjusting copper alloys for improved machinability, as well as desirable shop practice for the whole range of commercial alloys, whether very tough or very free-machining, are well brought out.

The clarity of expression that has characterized prior publications of the C.D.A. is maintained in this.—H. W. GILLETT.

Spectroscopic Tables

WAVELENGTH TABLES. *By George R. Harrison. Published by John Wiley & Sons, Inc., New York, 1939. Cloth, 8x11 in., 460 pages. Price $15.00.*

The task of reviewing this massive volume is not so horrendous as it appears, for only 18 of its 460 pages are text, and included in these are a few introductory tables. The book consists chiefly of 429 pages of data tables of practical value to the working spectrographer, and it will be these pages that will be well-thumbed and stained not long after purchasing.

Table I summarizes the number of lines included for each of the elements (except Nos. 43, 61, 85, 87 and 91) and for band heads, and Table II lists the symbols used in the wavelength tables. Table III compiles 500 of the sensitive lines of the elements arranged alphabetically, and Table IV arranges these lines in order of wavelength. Table V is the key to symbols employed for authors and references throughout the main body of tables, which follow.

Starting with a wavelength of 9999.7, Co, and ending with 2000.04, Mo, there are almost 110,000 lines listed with the intensity in arc, spark, or discharge tube, the stage of ionization of the parent atom, and, as mentioned previously, the wavelength authority. Included are a number of short wavelengths (observed at M.I.T. by the editor and his assistants) but not previously given and therefore only tentatively assigned to the element. Except for this, the element assignment is that of previous investigation.

The tables, "designed principally for use in spectroscopic analysis of materials and for identifying impurities," admirably fulfill the purpose. No spectroscopic laboratory can do without this reference book. Dr. Harrison and his co-workers, including a number of W.P.A. employees, have earned the gratitude of spectroscopists everywhere. The type is easy to read and the buff-tinted paper is designed to be easy on the eyes. The book is well bound, opens readily, stays flat and will likely stand a lot of laboratory table abuse. In a tabular work of this nature there must be some mistakes. So far only one has appeared and that is obviously a typographical error that cannot easily mislead.—THOMAS A. WRIGHT.

Blast Cleaning of Metals

MODERN BLAST CLEANING AND VENTILATION. *By C. A. Reams. Published by Penton Publishing Co., Cleveland, Ohio, 1939. Cloth, 6¼x9¼ in., 208 pages. Price $4.00.*

Sand blasting, shot blasting, hydroblasting, the equipment therefor and ventilation and other hygienic precautions are discussed from the engineering point of view. The author is an engineer with the Ford Motor Company.

The beneficial effect of shot blasting upon fatigue-resistance of springs and axles, the easing-up of cleaning requirements through controlled atmosphere annealing, and preparation for metal spraying are features of additional metallurgical interest, outside of the main topic.

The discussion is concise and clear, with special emphasis on the factors making for quality of work, speed of operation, and safety and convenience of the workmen.—H. W. GILLETT.

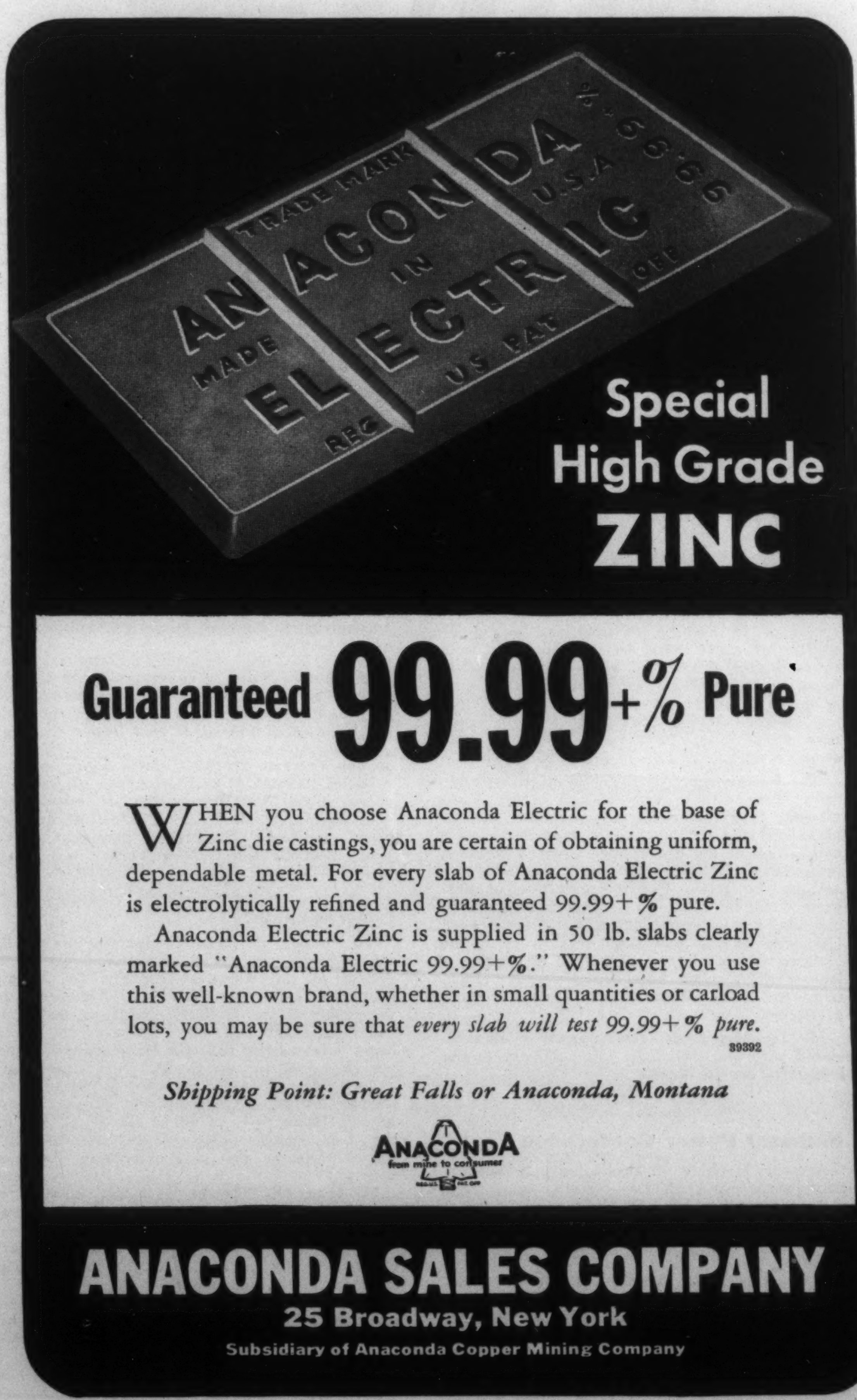
Other New Books

ALUMINUM ALLOYS—PATENT COLLECTION (Aluminium-Legierungen Patentsammlung). Second section of First Supplementary Volume to Part A of Gmelins Handbuch der anorganischen Chemie, 8th Edition. *By A. Grützner & G. Apel. Published by Verlag Chemie, Berlin, 1939. Cardboard, 7x 10¼ in., 606 pages. Price 49.50 RM.* Continuation of the patent index reviewed in METALS AND ALLOYS, Vol. 10, Nov. 1939, p. MA 682.

WROUGHT IRON. 2ND EDITION. *By James Aston and Edward B. Story. Published by A. M. Byers Co., Pittsburgh, 1939. Cloth, 6¼ x 9¼ in., 97 pages. Price $1.00.* Some new material, bringing the handbook up to date.

THE MINERAL INDUSTRY DURING 1938. VOL. 47. *By G. A. Roush. Published by McGraw-Hill Book Co., Inc., New York. Cloth, 7 x 9½ in., 784 pages. Price $12.00.* Information and statistical data, supplementing Vol. 46 for 1937, brought up to date and concisely presented.

PHYSICAL PROPERTIES OF PLATINUM (Physikalische Eigenschaften des Metalls) Part B, Section 2, of Gmelins Handbuch der anorganischen Chemie, 8th Ed., System No. 68: Platinum. *Published by Verlag Chemie, G.m.b.H., Berlin, 1939. Paper, 7x10¼ in., 107 pages. Price 12.75 RM.* Covers optical, magnetic, and electrical properties, with literature cited up to early 1939.



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CURRENT news

Courses in Industrial Radiography

Because of the increasing importance of X-ray procedures in testing materials in various branches of industry and art, New York University, New York, has scheduled three courses in industrial radiography as part of the science program of its Division of General Education. Believed to be the first offerings of its kind in any university in this country, the new courses will begin Feb. 1. Herbert R. Isenburger, president of the St. John X-Ray Services, New York, will be in charge.

Designed primarily for engineers and others whose work involves the scientific testing of materials, the new courses will include both a series of 15 evening lectures and an opportunity for those who desire laboratory work to familiarize themselves with actual practice in an industrial X-ray laboratory. In order to accommodate engineers from out of town provisions have been made to enable the laboratory work to be taken in 30 hrs. on 5 consecutive days.

The lecture course will comprise, in addition to a study of the various parts of an X-ray machine intended for metallurgical use, an explanation of the photographic procedure and a description of the use of the X-ray in welding, in foundry practice, in various other industries and in the arts. The interpretation of exographs will be discussed as well as the principles and applications of gamma-ray techniques. Questions of cost will also be taken up in the lectures which will be illustrated by means of lantern slides taken from actual practice. Field trips to X-ray laboratories have also been scheduled.

Mr. Isenburger has been for many years associated with Dr. Ancel St. John, pioneer in the industrial use of X-rays.

Midwest Power Conference

Armour Institute of Technology, in cooperation with seven middle western universities and colleges and several local and national technical societies, is again sponsoring the annual Midwest Power Conference to be held in Chicago, April 9 and 10, 1940, in the Palmer House, under the direction of Stanton E. Winston, 401 S. Quincy St., Hinsdale, Illinois, Associate Professor of Mechanical Engineering at the Institute. Charles A. Nash, 4715 N. Spaulding Avenue, Associate Professor of Electrical Engineering at the Institute, is secretary of the 1940 Conference.

Another Air Conditioned Blast Furnace

As a result of the successful operation of the world's first air conditioned blast furnace at the Woodward Iron Co., near Bessemer, Ala., an order from the same company for a duplicate air conditioning system has been announced by E. T. Murphy, vice president in charge of marketing, Carrier Corp., Syracuse, N. Y.

The original air conditioned dry blast furnace was put into operation in June, 1939, and according to reports from Carrier engineers, has "already produced a noteworthy reduction in fuel consumption per ton of iron with an accompanying increase in the maximum output of the furnace."

- Arthur R. Elsea, a recent graduate of Ohio State University, has joined the research staff of Battelle Memorial Institute. He will assist in a fundamental study of cast iron metallurgy.

- The Franklin Institute of the State of Pennsylvania has made its first award of the Vermilye Medal "in recognition of outstanding contribution in the field of industrial management" to Lewis H. Brown, president of the Johns-Manville Corp., New York.

Congratulations:

To Stanley P. Rockwell for the highly deserved honor—the Albert Sauveur Achievement Award of the American Society for Metals, bestowed at the National Metal Congress—development of the Rockwell hardness tester.

To James P. Gill, chief metallurgist, Vanadium Alloys Steel Co., for his elevation to the presidency of the A. S. M.

To Robert F. Mehl, Charles S. Barrett and Gerhard Ansel, as co-recipients of the Henry Marion Howe Gold Medal of the A. S. M., for the best paper published in the society's *Transactions* in the year preceding the convention.

To Oscar E. Harder, assistant director of Battelle Memorial Institute, on his election as vice president of the A. S. M.

To Zay Jeffries on his receipt of honorary membership in the A. S. M., bestowed at the National Metal Congress.

To A. E. White, director, department of engineering, University of Michigan, for his being conferred with founder membership in the A. S. M.

(Crowded out of the December issue)

New Bearing Alloys and Automotive Progress

Outstanding engine endurance records both in the air and on land, which are being achieved with increasing frequency, eloquently tell the story of improvements in the design and materials employed in the vital parts of these powerplants, says Charles B. Bohn, president of the Bohn Aluminum and Brass Corp., Detroit. "We have come to read in the public press of record long distance flights of commercial and private planes and of mass flights by military units over long distances without difficulty," states Mr. Bohn. "Behind these stories of accomplishment there is an untold tale of metallurgical development which is fascinating even to those engaged in this industry.

"In order that these planes can unfailingly make these long flights, or that the less spectacular, but even more important motor truck or motor bus, can day in and day out, carry on its arduous duty over the highways, it has been necessary to develop the metallurgical and engineering phases of bearing materials and design to a degree undreamed of only a few years ago.

"The automotive era is perhaps 40 yrs. old but the development of bearings, which after all are the key to endurance, has been more rapid in the past 3 yrs. than in all the other years put together. It must be remembered in this connection, that, in spite of the fact that engine outputs per unit of displacement have gone up tremendously, the bearings, which must carry these increased loads, have been developed sufficiently rapidly not only to take care of the added load but to reach endurance levels which actually astonish powerplant engineers themselves.

"Materials are now being used for aircraft, motor truck and motor bus bearings which initially are far more costly than materials employed in former years. However, the economy of the investment in these bearings is so unmistakable and clear in the service returned, that manufacturers of units employed in heavy duty work readily recognize the advantages of employing these materials. Probably outstanding in the utility materials for heavy duty truck and bus work are the copper-lead alloys. Silver, cadmium and other metals are also called upon in specific instances.

"The point which is of the utmost interest, is that the engineer who specializes on bearing design now has at his disposal such a wide range of materials and processes that he can engineer, both from the metallurgical and design standpoint, the proper bearings for any definite unit. It is this ability which lies behind, and is responsible for, the amazing stories of reliability and endurance which have now become so frequent as to be almost commonplace."

Powder Metallurgy at Stevens Institute

Stevens Institute of Technology, Hoboken, N. J., announces the organization of a division in powder metallurgy, and the appointment to its faculty of Gregory J. Comstock as associate professor of powder metallurgy, and of Claire C. Balke as assistant professor of powder metallurgy. The project is sponsored by a number of industrial concerns actively engaged in the production of products made by the methods of powder metallurgy. The division will present advanced instruction and carry out fundamental research in the metallurgy of metal powders. A research laboratory is now being equipped at the Institute.

Mr. Comstock, a recognized authority in the field of powder metallurgy, has contributed new and improved methods and techniques to the art. Mr. Balke for a number of years has been conducting research on the preparation, properties, and uses of metallic powders, principally those of the refractory metals, in the laboratory of the Fansteel Metallurgical Corp., N. Chicago, Ill. They will offer two evening courses at Stevens during the second semester, beginning Feb. 5, 1940, their subjects being "Powder Metallurgy" and "Powder Metallurgical Laboratory." This newly organized division supplements graduate work in some phases of metallurgy which has been conducted for some time.

(Continued on page MA 55)

A.F.A. 1940 Apprentice Contest

Following a plan initiated in 1925, the American Foundrymen's Association through its Apprentice Committee is sponsoring an apprentice molding and patternmaking contest to be held in connection with the Association's 1940 annual convention and foundry exhibition. The plans provide for local group and plant competitions to select entries for the national meeting, May 6 to 10. First, second and third prizes will be awarded in each of the four contest groups; Gray iron molding, steel molding, non-ferrous molding and pattern making. Any plant or group of plants employing certified apprentices is eligible to conduct a local contest and forward its best selections to the national meeting. An individual plant can send one entry in each of the four competitions, while a local group may submit three entries in each of the four competitions. In 1939 some 150 foundries and pattern shops participated.

- Jerome Strauss, vice-president in charge of research and development for the Vanadium Corp. of America, recently moved from the laboratories in Bridgeville, Pa., to the general executive offices at 420 Lexington Ave., New York.
- On Dec. 1, F. M. Ruggles of the Mullite Refractories Co., Shelton, Conn., assumed his new duties as the company's midwest sales representative with headquarters in Chicago. Mr. Ruggles is a graduate ceramic engineer and enters the sales field with a technical background in refractories. His territory will include Illinois, Wisconsin and Missouri.
- The Wheelco Instruments Co., Chicago, has recently appointed the Rodgers Engineering Co., 204 Thomas Building, Dallas, Texas, as its representative for the North Texas territory with Dallas as headquarters.
- Dr. Victor Paschkis, formerly of the A. F. Holden Co., is now with the Ajax Electric Co., Inc., Philadelphia.
- Dr. C. L. Mantell, consulting chemical engineer, announces the removal of his office from 360 Furman St., Brooklyn, to 136 Liberty St., New York.

Free Service Department

Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd St., New York.*

POSITION WANTED: Metallurgist, eight years' experience in steel mill development control, and claim investigation. Degrees B. Met. E. and M. S. E. from prominent universities. Experience covers tin plate, auto body and enameling sheets. Interested in research of coating problems or contact work. Box MA-1.

HELP WANTED: Salesmen: Acquainted with grey iron and non-ferrous foundry trade. To talk to grey iron foundrymen and introduce a superior patented material which meets their needs. U. S. and Canadian territories open. Auto needed. Write for details and assignment; give brief history of experience and qualifications. Box MA-172.

POSITION WANTED: Physical metallurgist, nine years teaching and industrial research, publications. Desires industrial, research or teaching position, preferably in midwest. Age 32, married, now employed. Box MA-173.

POSITION WANTED: Executive or chief engineer available. At present in charge of research and engineering and manager of manufacturing, purchasing and marketing of a company division being discontinued because of the sale of patents to another company. Box MA-174.

POSITION WANTED: Welding control engineer or superintendent. Age 30. Education college equivalent. 10 years' experience in boiler and pressure vessel fields. Physical, metallurgical, and radiographic laboratories, shop inspection and testing. Procedure set-up, training and qualification of welders. Thoroughly familiar with ASME, ASME-API and Pipe Codes. Member, ASME, ASM, AWS, ASTM, and hold National Board Certificate. Now working. Available January 1, 1940. Box MA-175.

POSITION WANTED: Chemist-Librarian. Young man, Harvard-trained, with experience in analysis of glass and refractories and particularly in translating and abstracting foreign technical literature. Reads Russian, French, German; now an abstractor for METALS AND ALLOYS, *Chemical Abstracts*, *Ceramic Abstracts*, and industrial firms. Box MA-176.

Solving Tricky Welding Problems

"Welding Hints" is a new service recently inaugurated by the Harnischfeger Corp., Milwaukee. This service is designed toward effecting savings of money and time—and maintaining machines, making emergency repairs, and replacing or rebuilding worn parts.

The "Welding Hints" consist of new and puzzling welding problems together with their solutions. They are printed on handy cards; and new additions to the series are made regularly. Each card handles a specific problem. Some of the problems dealt with are: The rebuilding of worn parts such as dipper teeth, side cutters, mining machinery, farm implements, etc.; building up of cutting tools; making of welded gears; rebuilding of sprocket teeth; welding of pipe structures; reclaiming of clutch pinions; and fast welding for poor fit joints.

Officers of A.W.S.

George T. Horton was elected president of the American Welding Society at the final sessions of its 20th annual convention at the Stevens Hotel. Mr. Horton succeeds Harry C. Boardman. Other officers elected were:

First vice-president, T. C. Smith; second vice-president, L. S. Moisseiff; directors-at-large: E. V. David, J. D. Gordon, G. F. Jenks and H. S. Smith.

- Joseph T. Ryerson & Son, Inc., of Chicago, have recently become distributors of McKay Certified Stainless Steel Electrodes. These highly specialized electrodes, covering the whole range of analyses encountered in stainless-steel welding, are stocked by all the Ryerson branches. A certificate of weld-deposit analysis accompanies every waterproof package sold.

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trends

By Edwin F. Cone, Editor

The Chemical Show

Another "chemical show" has come and gone, a biennial affair. This event is one that is of increasing interest to metal men. More and more are metals and their alloys essential to chemical processing. And in such a display, we see each year increasing evidence of this. The holding of this affair only every other year is an excellent plan which could possibly be followed by others. It has its distinct advantages.

Bright Hardening

Much has been said about bright annealing and many furnaces with suitable atmospheres are in use. This was not the case only a few years ago. At the National Metal Exposition a bright hardening furnace for tool steel and other material was a display that attracted many heat treaters. A paper on it was also on the program.

Sponge Iron

Imports of sponge iron have been on the increase. To Nov. 1, last year, the total had been 1531 gross tons against 380 for the same period in 1938. One cause of this increase is the greater demand for this Swedish product for use in powder metallurgy.

Steel Rails

The trend in the production of steel rails by American mills has been downward in the last 5 years. In that period, according to the American Iron and Steel Institute, the annual output has been a little less than 1,000,000 tons. The peak in output was about 3,200,000 tons per year from 1905 to 1913. From 1926 to 1929 the yearly average was about 2,800,000 tons.

Steel Officials' Share of the Pay Roll

Officials of steel companies in 1937 received 3.8 cents out of each $1.00 of pay rolls disbursed to employees, says the American Iron and Steel Institute. In 1929, steel company officials received nearly 7 cents of each pay roll dollar.

BeO As A Refractory

We were shown recently a fairly large crucible of beryllium oxide and the statement was made that results from its use were highly satisfactory. From another source we authoritatively learn that this material as a refractory has a bright future, due largely to its heat conductivity and its freedom from thermal shock.

Air Conditioning the Cupola

We learn that air conditioning is being experimentally applied to the cupola, paralleling the same trend for the blast furnace. This step is logical and no doubt regulation of moisture and other conditions making for uniformity of the blast will result in more efficient cupola operation.

Quarter Century Steel Expansion

When the World War began in 1914, the American capacity for steel ingots and castings was 39,689,265 gross tons. In 1939, at the time of the second or European war, the capacity was 73,061,569 tons. This is an increase for the 25 years of 84.2 per cent, certainly a broad expansion.

Steel Prices and Wages

Improvements in manufacturing methods have been the major cause of a reduction in prices of representative iron and steel products of 50 to 75 per cent from the levels prevailing 70 to 100 yrs. ago, according to a study made by the American Iron and Steel Institute. In contrast, the trend in wages has been the opposite—in the past century the hourly wages in the steel industry have increased nearly sevenfold, from 13 cents to more than 83 cents per hr.

Pig Iron for Japan

Except for the war year 1917, exports of American pig iron in 1937 and 1938 have been the largest on record. They were 782,400 gross tons in 1917. Japan has been the leading purchaser, taking 52.3 per cent of the total exports in 1937 and 73 per cent in 1938. In 1917 only about 10 per cent went into Japan. These larger pig iron purchases by Japan parallel her heavy buying of our iron and steel scrap.

Courses in Industrial Radiography

New York University will establish on Feb. 1 three courses in industrial radiography. This is believed to be the first offering of its kind in any American university. It parallels the trend among educational institutions in starting courses in powder metallurgy.

Nickel

Based on data to Nov. 1, 1939, world consumption of nickel in all forms was 206,000,000 lbs. In 1938 and 1937 the corresponding totals were 160,000,000 lbs. and 201,000,000 lbs. respectively. In his review of the nickel industry in 1939, Robert C. Stanley, president of the International Nickel Co. states that "the world undoubtedly will use more nickel in 1939 than in any previous year in the life of the nickel industry."

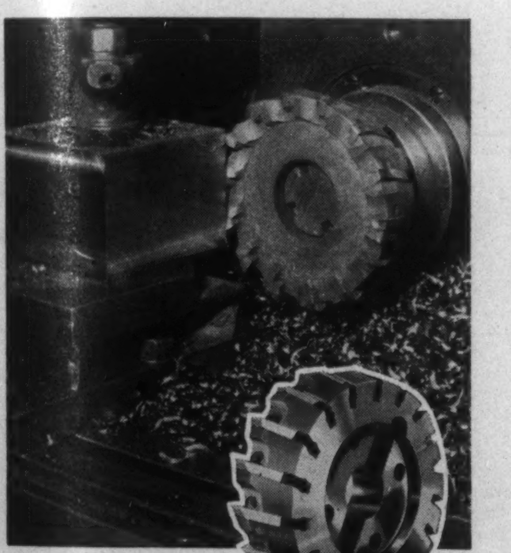
(Other "Trends" on page MA 58)

New Equipment and Materials

Milling Cutters

McKenna Metals Co., 158 Lloyd Ave., Latrobe, Pa., announces a new series of milling cutters equipped with Kennametal-tipped blades, which have been developed in cooperation with the McCrosky Tool Corp., Meadville, Pa.

The fast machining speeds and high resistance to wear found in Kennametal-tipped single point cutting tools are also characteristic of the new milling cutters. In the job illustrated, the 7-in. diam. standard McCrosky Jack-Lock Shell End Mill tipped with Kennametal grade KM is milling an S. A. E. 4150 steel forging that was heat-treated before machining to a hardness ranging from 28 to 32 Rockwell C. The cutter is run at 92 r.p.m., or approximately 5 times as fast as was possible with a cutter equipped with high speed steel blades. The feed is 3⅜ in. per min. and the depth of cut 0.125 in. An average of 160 faces were milled before regrinding was necessary, which was a much longer run than could be made with high speed steel blades.



The new series comprises 9 standard sizes in each of the following types of cutters: Medium duty face mills, heavy duty face mills and shell end mills. Incorporated in these milling cutters are exclusive features developed by McCrosky engineers which are particularly advantageous when using blades tipped with the hard carbide material, Kennametal. The Jack-Lock Wedge locks the blade with extreme rigidity and may be locked and unlocked without pounding, thus avoiding damage to the blades. In addition, the special adjusting screw in back of each blade permits fine and accurate forward adjustment that holds to a minimum the amount of expensive carbide material which must be removed to align all blades when regrinding. Blades may be moved forward as little as 0.002 in. These design features are shown in the 18 blade facing mill illustrated.

Manufacturers are invited to send to the Editor items which are suitable for this Department. Illustrations are acceptable, preferably in the form of cuts not more than 2 in. wide.

Universal Marking Device For Round Shafts

A universal marking device which permits marking directly on the O. D. of shafts, rods, etc., has been introduced by New Method Steel Stamps, Inc., 143 Jos. Campau St., Detroit. Designed for the optional use of solid or low cost individual type, the device consists of a type retainer and a guide holder.

The bottom of the guide holder is in the shape of a wide "V," so proportioned that the sides of the V-guide will rest against virtually any round shaft, providing a support on both sides to positively align the type and insure clear marking on center. The type retainer floats in the guide but its travel is limited by a pin in the guide extending into an elongated hole in the type retainer. Type retainers thus cannot drop out of the guide, yet have sufficient freedom of movement to rest directly on the shaft to be marked.

Individual type is retained in the retainer by means of set screws. To remove the type retainer from the holder, the pins are merely retracted against spring pressure by means of the knurled knobs. A hardened and ground anvil is provided in the type retainers to prevent type from "sinking."

Cutting Speed Conversion Tables

Cutting Speed Conversion Tables, showing the revolutions per minute required for turning bar stock at surface speeds of 90 to 550 ft. per min. with Kennametal steel-cutting carbide tools, have just been made available by McKenna Metals Co., 158 Lloyd Ave., Latrobe, Pa.

Printed on both sides of heavy paper, these tables are useful to time study men, tool designers and machinists. They permit quick determination of the nearest spindle speed to the best cutting speed when using Kennametal for turning various diameters of work. These tables should be used in conjunction with the chart of "Materials Machined with Kennametal," which gives the recommended surface speed for machining steels and other materials with this new hard carbide material.

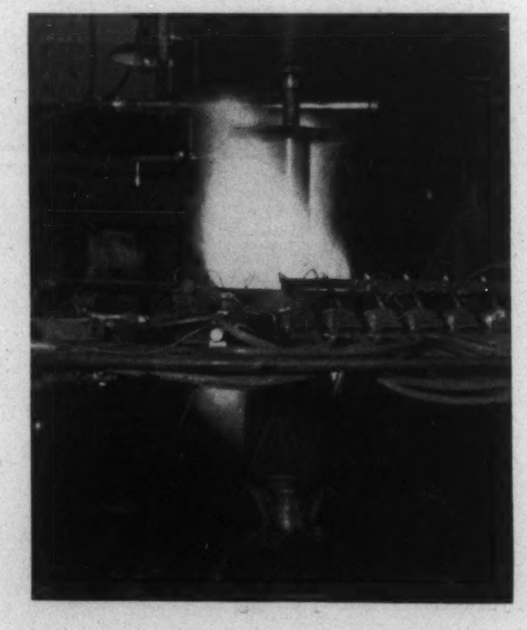
The formula for determining the correct horse power to prevent stalling of machines is set forth at the beginning of the tables. Copies of the new cutting speed conversion tables, as well as of the charts "Materials Machined with Kennametal," will be mailed free to interested readers upon request.

Flame-Hardening Process

A higher degree of hardness in steel and alloy iron rolls, mandrels, etc., is being obtained by a new flame-hardening process developed by Linde Air Products Co., and in operation at the plant of Farrel-Birmingham Co., Inc., Ansonia, Conn., according to T. V. Busk of that company.

This new process is known as the "Vertical Combination Method." By using it Farrel-Birmingham are able to raise the hardness of a .65-.70 carbon steel cylindrical object to approximately 90 or better on the Type "C" Scleroscope. They have also tested the process considerably in hardening a special dry sand alloy cast iron known as "Farreflame," and have obtained an average hardness of 80 on the Type "C" Scleroscope.

Another advantage of this new flame-hardening process, according to Farrel-Birmingham, is the fact that in all the rolls that have been flame-hardened by the Vertical Combination Method no measurable distortion has been detected. Overlap from the flame of the old progressive method of hardening is eliminated because the new process is continuous, uses a large number of flame tips and is followed immediately by a water spray quench.



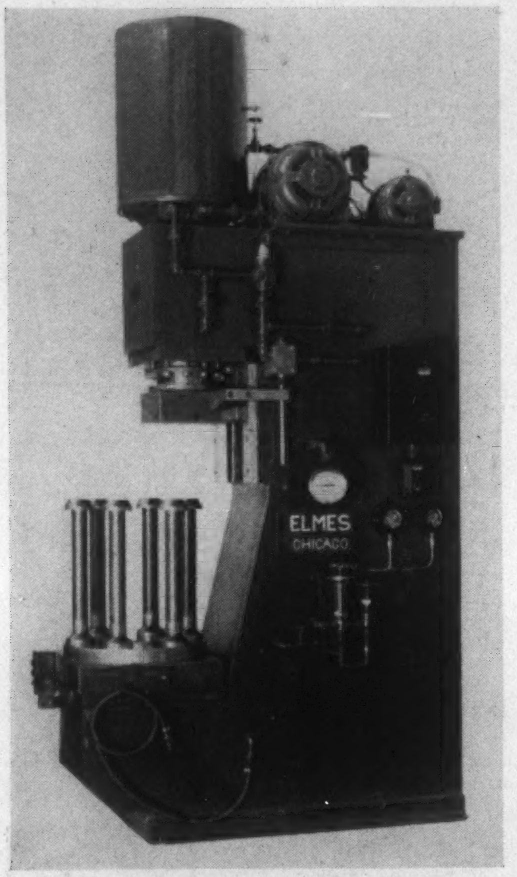
The Vertical Combination Method has proven very advantageous in many applications. Among these are the following: Rubber engraving rolls, embossing rolls, calender rolls under certain conditions, different types of mandrels where excessive pressure or wear must be taken into consideration, certain applications for rolling mills, dough machines, wearing surfaces of bearers in printing machinery and numerous other applications.

Full information regarding this new process of hardening will be furnished by Farrel-Birmingham Co., Inc., to interested executives and engineers who care to write to the company's offices at Ansonia, Conn. The illustration shows a roll being flame-hardened by the new method.

Metal Marking Press

A new versatile hydraulic metal marking press has just been announced by the Charles F. Elmes Engineering Works, Chicago. This press, it is said, will die stamp any marking on metal pieces of a wide range of sizes and shapes, and is capable of 20 markings per min.

The operation is fully automatic and is controlled by push buttons. There are 6 stations on the turn table. The table may be moved independently of the ram and vice versa. However the machine is arranged so it will not stamp a blank mandrel. The pressure may be released at a pre-determined tonnage or after the die has marked the work to a specified depth.



The range of pressure is controllable from 15-tons to 100-tons. The machine is all steel construction and has an overall height of approximately 11 ft. It includes motors, starters and accessories ready for operation. It is modern in design and appearance.

Addition Agent for Pickling Baths

An addition agent for pickling baths called "Pickleen" has been announced by The Enthone Co., 442 Elm St., New Haven, Conn. This addition agent is stated to effect a marked lowering in the surface tension of sulphuric or hydrochloric acid pickling solutions which results in saving of acid by drag-out. The addition of Pickleen, according to the manufacturer, also results in a saving of acid by an inhibiting action, but the product is not claimed to be an inhibitor.

It is claimed that the acid pickle containing the addition agent functions also as a cleaner, thus enabling smoother and more rapid pickling action on iron or steel which has not been thoroughly cleaned of all grease or oil. The cleaning action, therefore, is reported to help insure proper adhesion of plated coatings after acid dipping, by removing any oil films remaining after alkaline cleaning or normally liberated as fatty acids in the pickle if complete rinsing of the cleaner was not done. It is said to be particularly effective for pickling parts in bulk for barrel plating, hot tinning, or galvanizing, because complete cleaning is difficult to accomplish in bulk or basket cleaning.

Pickleen is claimed to be stable in hot sulphuric acid solutions up to 15% concentration and in cold hydrochloric acid up to 1:1 concentrations by volume. Literature and sample can be secured by asking for Bulletin No. 25.

Metal Screen Made by Electroplating

A new and unique development, made possible by newly perfected electro-forming methods, is found in the production of metal screens. The fabric is built up as a one-piece, solid metal product wholly by electrodeposition. No woven or other foundation structure is included in the deposit.

The product is designed to serve purposes lying between those now covered by perforated metals on the one hand and woven wire screen on the other. It is claimed to combine accuracy in hole diameters with the smooth surface characteristic of perforated metals. Its percentage of openings lies between 16 and 50 per cent of the total area, depending on design. These figures are said to be comparable with those obtainable in woven wire mesh. Generally, the electroplated screen is used in the fine meshes below the limits of perforated metal. Essentially, it supplements rather than competes with conventional woven wire.

The plated screen, known by its trade name of "Lektromesh," presents a smooth surface and is readily fabricated by drawing, stamping, welding, soldering and the like. It is stiff, tough and strong. Another special feature is the latitude in design which it makes possible. The mesh can be of any shape and of a variety of sizes. It has a unique quality in the fact that in some sizes and designs a 2-in. piece may be stretched to 1 ft. It also can be designed to avoid heat conduction. Since it is an integral structure, it will not unravel.

"Lektromesh" screen has been produced in nickel, copper and other materials. Continuous production methods are used with such success that screen has been made in rolls 36 in. wide and up to 1400 ft. in length, it is reported. In manufacture the desired design is transferred by a succession of sensitizing, etching, filling and surface treating processes to a metal plate or matrix.

These operations leave the metal surface of the matrix in a condition to receive the electrodeposit uniformly where desired and yet allow it to be withheld where open spaces are necessary. The matrix when completed with its exposed and masked sections is fastened to a circular cylinder which revolves in the plating bath. As the cylinder revolves, the metal deposits are built up evenly and uniformly on the exposed areas of the matrix. Thickness of the deposit depends on the current density used and upon the speed at which the cylinder turns. The deposit in the form of a continuous sheet of screen is stripped off the matrix automatically.

Commercially, "Lektromesh" has been produced in sizes from 25 to 400 mesh, with the bulk of production to date lying between 25 and 150 mesh. "Wire sizes" have ranged from what in round woven wire would be 0.0008 to 0.025 in. in diameter.

Though "Lektromesh" comes as a relatively new development, commercially it already has established important applications. One of these is for strainers in fuel systems which can be produced in multiples to accurate shape and size in sheet form and then punched from the sheet without requiring any further fabrication. Another has been for the screens on radio loudspeakers and for clock dials. Here again, advantage lies in the fact that no limit is placed on design.

The complete processes of production are covered by patents held by E. O. Norris, Inc., under which the C. O. Jelliff Mfg. Co., Southport, Conn., holds exclusive rights.

Cold Tinning Compound for Aluminum

This new tinning compound for aluminum makes the use of tin-lead solder to be sprayed on to aluminum as simple as A.B.C., and eliminates special aluminum solders and fluxes, it is claimed. With this new tinning compound, it is said, the surface to be tinned is prepared in the usual way. A clean rag, moistened with water, is then dipped into the compound and rubbed over the surface to be tinned until a shiny metal coating is formed. This coating then forms a permanent bond with the tin-lead solder which is sprayed on thereafter.

Further details may be obtained by writing direct to the manufacturer, Glaser Lead Co., Inc., 29-31 Wyckoff Ave., Brooklyn, N. Y., mentioning this paper.

Stamping Tool

The Pittsburgh Stencil and Tool Co., 721 Crafts Bldg., Pittsburgh, manufacturers of Rick Markwell Holders for stamping steel and other products, announces a new tandem holder which is particularly valuable for stamping intensely hot metals.

This double line axe-type holder, with 3 pieces of type in each line, when swung like an axe, is much more likely to imprint all 6 numbers than one with 6 numbers all in one line. The only moving part is a sturdy pin, in each row of type, which carries its own spring. One quick motion locks it; another unlocks it.

PGH STENCIL & TOOL CO.
RICK
Markwell

Markwell holders, which handle type made for other holders as well as its own, employ safaloy type, a special alloy, which is practically unbreakable and makes for safe and economical stamping. Markwell holders come in all sizes from 1/16-in. type up to 1 in. or larger. Descriptive new literature is available.

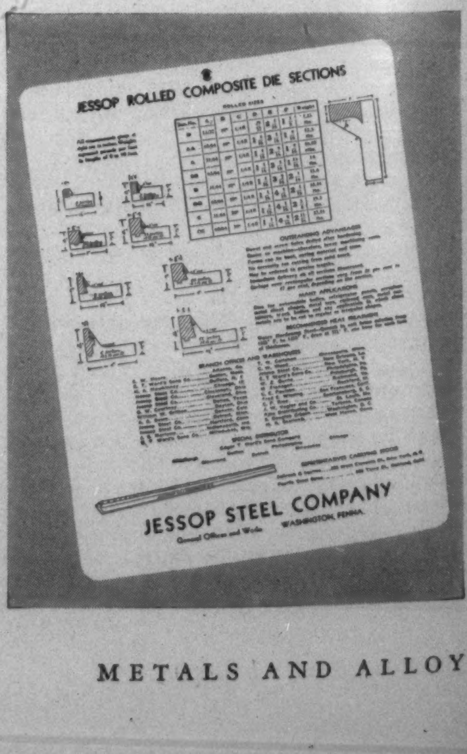
Wall Chart for Die Sections

The Jessop Steel Co., 546 Green St., Washington, Pa., has just issued a new wall chart which gives the specifications for their rolled composite die sections, used in dies for cutting sheet metal to regular or irregular shapes.

End views of 8 different die sections are illustrated, and the rolled sizes are listed in a readable table. Also included in the table are the weights per foot in lengths of 8 to 10 ft., varying from 7.25 lbs. for Section D to 23.94 lbs. for Section CC.

Among the advantages claimed for Jessop rolled composite die sections, as set forth in the new chart, are ease of machining and forming and the possibility of drilling dowel and screw holes after hardening. Savings over rectangular sections vary from 28 to 47%, depending on the section. Typical applications of sectional dies, ranging from railroad cars to metal toys, are given, as well as the recommended heat treatment for Jessop die sections.

The new chart has been printed on heavy, varnished cardboard stock to withstand rough handling, and has a hole punched at the top so that it may be easily hung from the wall. It is available to interested readers without cost.


JESSOP ROLLED COMPOSITE DIE SECTIONS
ROLLED SIZES
OUTSTANDING ADVANTAGES
MANY APPLICATIONS
RECOMMENDED HEAT TREATMENT
BRANCH OFFICES AND WAREHOUSES
JESSOP STEEL COMPANY
General Offices and Works
WASHINGTON, PENNA.

Bonding Soft Rubber To Steel and Aluminum

After several years of research and experimentation, Hewitt Rubber Corp., Buffalo, N. Y., has developed a method for bonding soft rubber and Neoprene to steel and aluminum by hot vulcanization which is said to result in exceptionally high adhesion strength between the rubber and the metal with remarkably good aging qualities. The processes employed by Hewitt for attaching rubber to metal are of a chemical nature. By means of this special chemical treatment the composition of the rubber is modified in such a manner that it will attach itself integrally to the metal and still retain its capacity to vulcanize itself to the outer rubber layer.

This process is called "Dura-Bond" and is based upon newly discovered methods of attaching soft rubber and Neoprene directly to steel and other metals, which results in an adhesion strength of 500 lbs. to 750 lbs. per sq. in.

The use of rubber-metal vulcanized combinations is rapidly increasing in the automotive, transportation and mechanical goods industries. These products combine the abrasion and corrosion resistance as well as the sound-damping properties of rubber with the strength and rigidity of metal.

With reference to the heat conditions for which Hewitt can safely recommend its "Dura-Bond" process, the company limits its recommendations to temperatures up to 200 deg. F. Endeavors to extend the range of high temperature service conditions to at least 250 deg. F. are being made.

Illustrated herewith is the largest steel cylinder ever rubber-covered by Hewitt. Hitherto no cylinder over 18 in. in diameter has been rubber coated by Hewitt. The cylinder in the illustration is 77 in. by 24 in. in diameter. It is used in the pickling bath division of an Eastern steel company. One inch of rubber covers the main body of the cylinder. Cylinder ends and a large portion of the shafts are also rubber-covered. With present equipment Hewitt is now able to rubber-coat cylinders up to two feet in diameter, with shafts extending up to 1½ ft. on either side.

Insulating Joints for Electro-Chemical Pipe Lines

Plants employing electrochemical processes such as electroplating, electrotyping or electrorefining have a constant problem—the possibility of electrical grounds through the pipe lines transmitting solutions. To eliminate this danger, the best practice is to use insulating joints in the lines.

A complete assortment of such insulating joints is obtainable from the Hanson-Van Winkle-Munning Co., Matawan, N. J. These joints, simple in construction, are made of malleable iron and include compressed fiber insulating rings which encircle the ball member at two different places. They are tested for 125 volts direct current service and for 200 lbs. per sq. in. steam pressure. They may be safely used under hydraulic pressures as high as 1000 lbs., depending upon the size of the joint. Their flexibility is claimed another advantage, as it prevents pipe breakage due to expansion, contraction or vibration strains. Insulating joints are recommended for cleaning tanks, plating tanks and heating and cooling lines.

Non-Ferrous Anti-Slip Plates

The National Bronze & Aluminum Foundry Co., Cleveland, has brought out an anti-slip material for floor plates, stair treads, door saddles and so on under the trade name "Ten-Lox." It is described as a new use for cast aluminum, brass and bronze alloys.

The material comprises flat walkway surfaces or plates of the cast alloy in which pieces of aloxite, an abrasive produced in the electric furnace, are imbedded at regular spaced intervals. When furnished in the form of plates to be laid on existing floors or stairs, the metal usually is about ⅜-in. thick. In special forms for self-supporting treads, trench covers, platforms and the like, the design is adapted to the installation requirements and embodies necessary stiffening webs and flanges as well as connecting and attachment lugs.

The abrasive is in the form of irregular-shaped pieces averaging ½ to ¾-in. in each dimension. The pieces are spaced roughly 1 in. apart, center to center, and penetrate through the matrix from top to bottom.

Tests conducted by Underwriters' Laboratories, Inc., Chicago, reveal average coefficient of friction to be 0.74 on a dry test, 0.75 on a wet sample and 0.91 on an oiled sample.

In most instances the matrix material is SAE 33, an aluminum alloy containing 6 to 8 per cent copper, 2.5 per cent zinc, 2 per cent silicon, 1.5 per cent iron, 1 per cent impurities and the balance aluminum.

Cutting-off Machine

A new machine of the bonded-abrasive wheel type is announced by the American Instrument Co., 8010 Georgia Ave., Silver Spring, Md., for cutting glass, quartz, ceramics, metals, commercial and semi-precious stones, etc., in the form of sheets, rods, tubes, and blocks.

Cuts up to 3½ in. can be made on materials with flat surfaces. Rods, tubing, and the like up to 6 in. thick can be cut by rotating the material as it is being cut, it is claimed. True, clean cuts are made speedily and precisely by means of a motor-driven 12-in. diameter rubber-bonded abrasive wheel (0.04 or 0.06 in. thick)—without chipping or breaking the material.

The machine is claimed especially suitable for slicing all kinds of tubing, and makes extremely short cuts that are made only with great difficulty by other means. For example, lengths of 1½-in. diameter glass tubing as short as 1/32 in. can be cut off as easily and quickly as longer lengths, and with smooth, parallel, unchipped edges.

The machine consists essentially of a non-corrosive cutting table (adjustable for cuts of various angles), a cutting wheel direct-connected to a 115-volt 60-cycle a-c. motor, a centrifugal pump (for pumping water from a built-in pump to the spray heads that play steady streams of water upon the cutting wheel), mounted on a rigid steel stand.

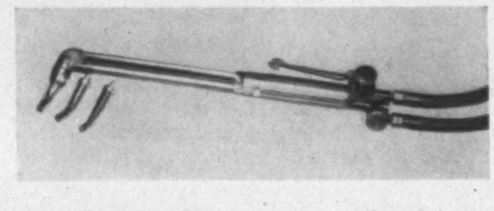
Control for Electric Heating Equipment

A new system for automatically regulating the power input to electrically heated equipments, such as furnaces, boilers, superheaters, and air heaters, has been announced by General Electric Co., Schenectady, N. Y. Called the Reactrol system, this new means of control regulates power input by varying the voltage impressed on the heating resistors in accordance with temperature or pressure requirements. It is particularly suitable for continuous processes and in the treatment of materials that might be affected by slight changes in temperature.

In its simplest form, the Reactrol system consists of a control panel, a temperature or pressure control instrument, and a saturable-core reactor. In operation, the pressure or temperature control instrument (which contains a special potentiometer) feeds low-voltage current into an amplifying tube on the control panel. This tube, in turn, regulates the flow of direct current to the saturable-core reactor which, acting like a valve, regulates the voltage applied and thus the amount of power going to the electric heating equipment. Thus, the Reactrol system provides accurate and rapid temperature or pressure control with practically no overshooting.

Nozzles for Oxy-Acetylene Gouging

A series of new oxy-acetylene gouging nozzles, for use with a standard hand-cutting blowpipe, such as the Oxweld C-32 cutting blowpipe, has been announced by The Linde Air Products Co., 30 E. 42nd St., New York. These new Oxweld nozzles, which are available in 3 sizes, provide a means for quickly and accurately removing a narrow strip of surface metal from steel plate, forgings, and castings.

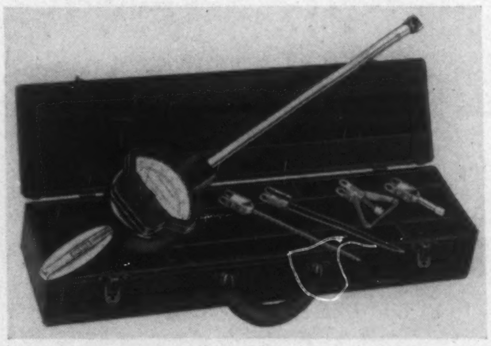


The nozzles are so designed as to deliver a relatively large jet of oxygen at low velocity. By proper manipulation of the blowpipe in which the nozzle has been inserted, a smooth, accurately-defined groove can be cut or ground out of the surface of the metal. By using various standard size nozzles and manipulations, the groove can be varied in width and depth at the will of the operator.

Important uses for these new nozzles are: Gouging the underside of electric welds; removal of weld metal, such as temporary tack-welds and defective welds; preparation of plate edges for welding; and maintenance and scrapping operations. A wide field of miscellaneous uses include gouging in metal-shaping and trimming processes.

Surface Temperature Pyrometer

The new "Wheelco" Surface Temperature Pyrometer, put out by the Wheelco Instruments Co., Chicago, has many of the qualities of a lightweight champion, it is claimed. It is fast and accurate in action, versatile, light in weight, yet rugged enough to withstand plenty of rough usage.



Wherever a correct surface temperature reading (up to 1200° F.) is required, a Wheelco Surface Temperature Pyrometer will provide it, it is said. The broad assortment of thermocouples completely covers the many types of work demanding reliable surface temperature indication. These instruments pay for themselves almost immediately in saving money on spoilage losses and in maintaining uniform quality, the company contends.

Electric Heat To Lubricate Chains Before Shipment

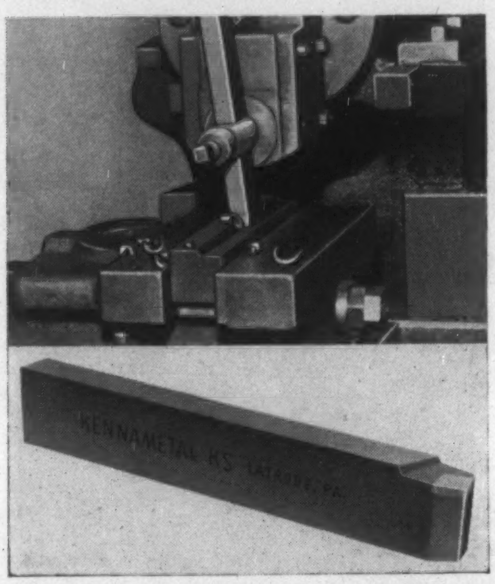
An unusual application of electric heat was recently made by the Diamond Chain & Mfg. Co., of Indianapolis, Ind. To assure perfect lubrication of chains before packing for shipment this company immersed them in a preloader containing a tank of electrically heated oil. The tank is constructed of ¼-in. sheet-steel with 3 in. of magnesia on the bottom and sides. Heat is provided by 66 General Electric strip heaters, having a total rating of 39 kw., clamped to the bottom and walls of the tank in 6 sections.

As the chains leave the lubrication tank, the excess oil is removed by a blast of compressed heated air. The air is heated electrically in a small cylindrieal tank before it is compressed. This tank contains two General Electric 500-watt immersion heaters. A 3-heat switch and automatic thermostat eliminates the necessity of manual temperature control.

Steel Cutting Shaper Tools

McKenna Metals Co., 158 Lloyd Ave., Latrobe, Pa., announces the development of standard steel-cutting shaper tools tipped with Kennametal grade KS, for use on shapers and planers to machine steel of hardnesses up to 550 Brinell. This is believed to be the first time that hard carbides have been regularly used on tools for shaping hardened steels.

A feature of these new tools is the unusual tool angles employed, namely: 10 deg. negative back rake, 5 deg. negative side rake, 15 deg. side cutting edge angle and 2 deg. clearances. These tool angles, which must be maintained when re-grinding tools for the best results, are made possible by the low frictional resistance between Kennametal and the work being cut.



As a result, less frictional heat is developed than when high-speed steel tools with conventional high side rake angles are used. This is demonstrated by the fact that chips from Kennametal shaper tools are straw colored while those from high-speed steel tools are a deep blue—using the same speed, feed and depth of cut in both instances. With these tool angles it is unnecessary to lift the tool on the return stroke.

Kennametal shaper tools will shape steel of hardnesses above the machinable limit for high-speed steel tools at speeds that are often double those used with high-speed steel tools on work in the lower hardness ranges. Die blocks of 42 Rockwell C hardness may be hardened before machining with Kennametal, it is said, saving the grinding operation that would be necessary if they were hardened after shaping.

Kennametal KS has a hardness of 76 Rockwell C but has a strength unequaled by any other hard carbide tool material; namely, 322,000 lbs. per sq. in. The sizes of tools furnished will fit standard clapper boxes of shapers and planers.

A Safety Goggle

The American Optical Co., Southbridge, Mass., announces a new "No. 303 Super Duralite-50 Safety Goggle" with a non-rubber headband. This new goggle is said to have not only all the proven advantages of the Duralite-50, but combines with them several important features which assure added comfort and long life.

The eyecups are molded from a special material that combines light weight for comfort with high tensile strength for long wear. This material is not affected by exposure to water, oil, grease, and perspiration. It can be sterilized by any method without harm. Anatomically designed, these eyecups have broad bearing surfaces, and are low set to provide wide angle vision.

The non-rubber headband consists of a spring and ball chain covered by a cloth sleeving. The chain prevents over extension of the spring, yet permits instant adjustment to any desired head size. When adjusted it maintains the same tension indefinitely but may be readjusted for different head sizes.

Lenses regularly supplied are the 6.00 curve clear super-armorplate type. The caps which hold the lenses in place are precision threaded to insure easy removal for replacement of lenses. Metal screens provide adequate ventilation.

A Sheet Gager

The Streeter-Amet Co., 4100 Ravenswood Ave., Chicago, has put on the market a sheet gager, known as the "Guyer Gager." It is reported to have been subjected to exhaustive tests in both the laboratory and in the field.

The Guyer Gager is a mechanical micrometer designed to produce a faster, simpler and more accurate means of checking the thickness or gage of metal sheets. In operation, the device clamps a sheet at any point the thickness is to be measured. The work is held at this point long enough for the operator to read the large, legible dial. It is then automatically released for removal from the machine or to the next point to be measured. The cycle of clamping, gaging and releasing is constantly repeated. The cycle frequency is under the control of the operator. By following the rhythm of the cycle, the operator can shift the sheet from point to point rapidly, obtaining readings in a fraction of the time required for hand "miking."

The standard machine will indicate from 8 to 38 gage readings per min., or any of the following reading ranges can be supplied, if specified: 9—42; 10—47; 11—50 per min. The throat of the machine is 23 in. deep clear of the measuring anvil which admits great latitude in exploring wide sheets for uniform thickness.

The mounting of the gaging mechanism is said to assure accuracy. The dial and measuring mechanism is carried by the two side members so mounted as to eliminate all errors due to deflection. The dial is graduated in 0.001 in. increments so that any desired gage or tolerance may be readily established by means of adjustable dial rim markers. The dial tolerances represent the accuracy requirements of metal forming, drawing and stamping operations.

Manganese Metal Powder

A new metal powder is now on the market, a powder of manganese metal of the highest purity. The powder has the following representative screen analysis:

+150 Mesh	Trace
+200 Mesh	0.8%
+250 Mesh	28.0%
+325 Mesh	56.3%
—325 Mesh	14.9%

Apparent Density: 2.75 grams per c.c.

Manganese metal of this purity and with these characteristics should find an excellent outlet in many fields, says *Metal Powder News,* published by Charles Hardy, Inc., New York. One promising application is that of an alloying addition agent, either by itself, or with other metal powders compressed into uniform weight compacts, thus assuring the correct proportion of each element making up the alloy. Other applications include magnetic and electrical alloys; the manufacture of welding rod; and also use in the chemical and pyrophoric fields.

Aridifier Line Complete

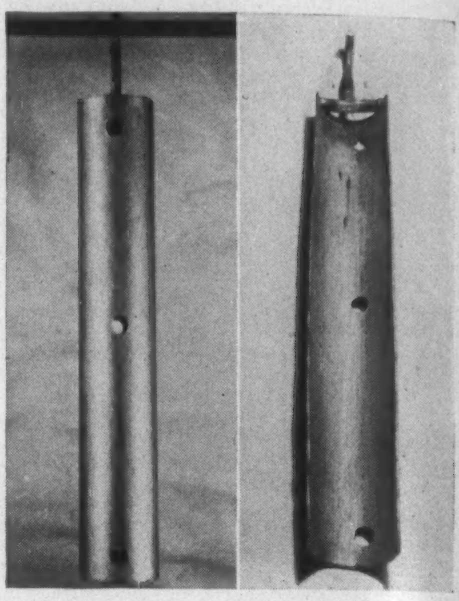
The Logan Engineering Co., 4912 Lawrence Ave., Chicago, announces that its line of "Aridifiers" for removing moisture and oil from air and gas lines is now complete in all sizes from ⅜ to 10 in. All sizes are said to effectively remove dirt and moisture from compressed air lines and gas lines, foreign matter impinging on a multiplicity of "propeller blades" revolving in opposite directions and propelled by the flow of air or gas. The arrested contamination and moisture is collected in the lower housing from where it is drawn off as occasion warrants.

All sizes are described as simply constructed, easy to install in any line, interior or exterior, to operate without back pressure and to require no maintenance or attention other than a periodical clean-out. These units are designed for application to all compressed air lines in foundries such as sand blast equipment, jolt machines, strip, draw and roll-over equipment, shake-outs, air driven chippers, hammers and grinders, etc.

Aridifiers are pictured and described in Bulletin 939 now available which gives complete operating and installation details on all units.

Tubular Anode for Chromium Plating

A tubular design of lead anode, stated to give unusually even throwing power and low resistance for the current-discharge surface available, is being manufactured by The Acme Lead-Burning Co., 3726 West 73rd St., Cleveland. It may be supplied of either pure lead or 6 per cent antimonial, as may be specified.



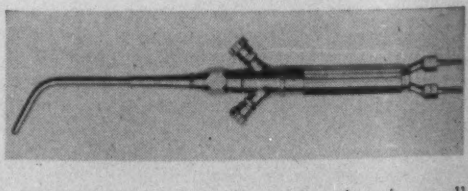
This type of anode is particularly recommended for the center anode busbars of a tank because of the equal current-distribution on all sides. For the anodes of the side busbars, the semi-circular pattern is recommended; or the ordinary flat anodes may be employed. It is claimed that because of the simple design and the smaller amount of lead needed, these tubular and semi-circular anodes cost less than the regular flat ones.

An Oxweld Welding Blowpipe

A new oxy-acetylene welding blowpipe, for welding light-gage metal, has been announced by The Linde Air Products Co., a unit of Carbide and Carbon Corp., New York. Although this blowpipe, known as the "Oxweld (Type W-29) Welding Blowpipe," was specially designed for welding in light production work and in aircraft construction, its field of usefulness extends to all applications in which metals up to ⅜ in. thick are to be joined.

Its light weight (15 oz.), small size, and slender lines make it unusually well suited to welding in relatively inaccessible places, or for production line work, it is claimed. Both valves on the W-29 are located at the forward end of the handle where they may be readily adjusted by thumb and forefinger, leaving the other hand free. The "pencil point" welding flame is concentrated yet "soft" enough for excellent control of the welding puddle.

Strongly constructed, the W-29 offers continued operation with a minimum amount of maintenance because of such refinements as "packless" valves and valve stems shielded against knocks. It features increased flash-back resistance, greater valve capacity than is usually found in blowpipes of this size, and—as another notable efficiency feature for this size blowpipe—small size screw-type hose connections on the blowpipe handle, which allow the use of 3/16-in. hose for full blowpipe capacity. There are 8 welding heads, each with a built-in injector, and each available in both the one-piece tip and the two-piece tip style. Either low-pressure or medium pressure acetylene can be used.



Further information about this blowpipe, which replaces the W-15 Welding Blowpipe in the Oxweld line, can readily be obtained from any office of The Linde Air Products Co.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

A Digest of
Important Developments
in the World of Metals

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1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

5. General

Articles pertinent to more than one of the previous sections.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

1a. Ferrous

High Strength Cupola Iron

"Cupola Possibilities and Limitations for Making High-Strength Iron." H. W. Gillett & C. H. Lorig. *American Foundryman*, Dec. 1939, pp. 5-11. Practical.

It is time right now for foundrymen to consider how they can produce high-strength iron and to lay definite plans for its production. The fundamental problem is considered by the authors to be the production of molten iron of 3.00% C and 1.50% or less Si, at a high enough temperature level to take up the addition and allow plenty of time for pouring. It is preferable to carry such work in the cupola because it is the cheapest melting method considering both first cost of equipment and fuel consumption. By using a charge high in steel, Si can be kept low and the desired S added at a later stage. The lowering of C and Si can be accomplished either by oxidation or by dilution with molten low-carbon steel.

It is fundamental in the oxidation of pig iron to steel or to iron of some intermediate carbon content that at the temperature of cupola metal Si and Mn have to be removed completely before C is attacked. Therefore, only an oxidation of Si followed by dilution of the melt with molten steel may be considered. Udy, of Chromium Mining and Smelting Corp., has proposed the use of silicon thermit and this material is being studied at Battelle Memorial Institute. Instead of using iron oxide and Al as the heat-generating agents, sodium nitrate and ferrosilicon are used. Just as in the converter, Si is oxidized before the iron, forming silica which is fluxed by the sodium oxide from the nitrate. If desired, some lime may be added as a further flux. The reaction generates enough heat to melt cast iron chips or steel clippings almost instantaneously. The iron is thus supplied molten and at a high temperature.

The mixture of nitrate, ferrosilicon and metal to be melted is termed "Fer X". A 100-lb. heat consisting of ¾ briquetted borings and ¼ heavy scrap was melted down in the basic induction furnace to a calculated composition of 3.35% C, 2.30% Si, 0.70% Mn, 0.10% S, and 0.18% P. It was treated with 1 lb. soda ash and the slag removed. Mill scale was then added, calculated to reduce Si to 1.65%. Slag was removed and "Fer X" was added for dilution of C and Si to 3.00% C, 1.50% Si and a final inoculating addition of 0.25% Si (as ferro silicon) was made. The metal was kept at 2850° to 2650° F. during the application of the various treatments. The pouring temperature was 2550° F. The finished iron analyzed 2.96% C, 1.73% Si, 0.55% Mn, 0.03% S, and 0.18% P.

The four 1.2-in. bars from this heat showed an average tensile strength of about 46,500 lbs./in.^{2}. The test does not prove that cupola metal and heated forehearth would be as easy to handle, but it does indicate that the chemistry of the process does work. Cost of method, borings briquetted, scrap versus borings, etc., are also discussed. AIK (1a)

Strip Steel Wheel Rims

"Strip Steel for Motor Car Wheel Rims." E. R. Mort. *Iron & Steel*, Vol. 12, Sept. 1939, pp. 712-714. Practical investigation.

The grain size of steel resulting from rolling mill practice was found to influence the behavior when subsequently rolled and welded into motor car wheel rims. That this might be so was first indicated when material purchased from a new supplier to rigid chemical specifications failed to function satisfactorily. An investigation revealed that the important features of mill practice were a fast continuous process to enable finishing at 1000° C. or higher and a rapid coiling to take full advantage of the "self-anneal". The new supplier rolled small batches, slowly finishing at 900° C. or lower, and the grain size was roughly half that of the former material, resulting in high hardness and increased susceptibility to work hardening.

Upon metallurgical analysis and recommendations the new supplier modified his practice to give suitable strip. The physical properties were as follows:

> *Old Supply*—yield pt., 30 - 35,000 lbs./in.^{2}; tensile strength, 50-55,000 lbs./in.^{2}; elongation in 2 in., 39-47%; Rockwell "B" hardness, 55-65; grain size, 0.0025 in. linear.
> *Unsatisfactory New Supply*—yield pt., 50,000; tensile strength, 70,000; elongation in 2 in., 42%; Rockwell "B" hardness, 65-75; grain size, 0.001 in. linear.
> *Modified New Supply*—yield pt., 29,600; tensile strength, 49,100; elongation in 2 in., 45.3%; Rockwell "B" hardness, 48 (grain size not given).

The best hot-rolled strip for deep drawing is produced on a fast, rapid-coiling, fully-continuous mill capable of finishing strip at a temperature high enough to give a grain size comparable to normalized stock. By modifying the mill practice to give strip of the above physical properties, the maximum average scrap was reduced from an intolerable figure to 0.7%. HFT (1a)

Ingot Mold Design

"Cooling Conditions in Ingot Moulds." *Foundry Trade J.*, Vol. 61, Nov. 16, 1939, pp. 335-336. An abstract of a paper by I. Ja. Granat and A. A. Besdeneshnych in the Russian journal *Metallurg*.

The authors investigated the cooling conditions with specially constructed circular ingot molds and with standard steelworks molds for ingot weights up to 7 tons. The factors that determine the soundness or quality of an ingot include the composition, the temperature, the rate of cooling, the rate of pouring and the heat removal at various levels across the ingot. In the lower parts of the ingot, the dissipation of heat is governed by the bottom plate, at the sides by the thickness of the ingot walls and at the top by convection and radiation to the surrounding atmosphere.

The conditions regulating the removal of heat from the ingot during the cooling period to ensure the production of a sound ingot are entirely different during solidification and subsequent cooling, for during solidification the extraction of heat must be greatest at the bottom and gradually diminish towards the top of the ingot. To obtain minimum ingotism, the rate of cooling must be high, while to avoid cracks and other defects the rate of cooling must be retarded during the second stage.

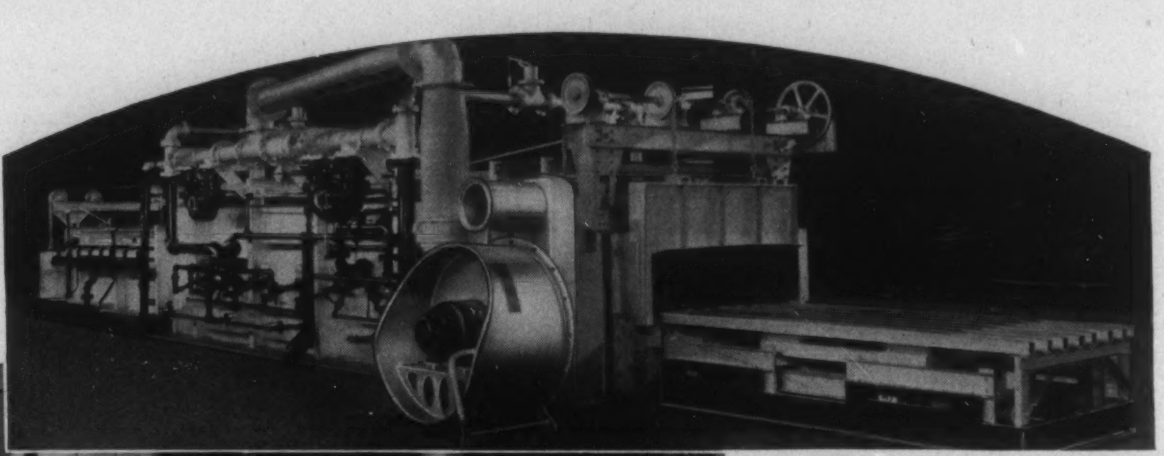
From their investigation the authors conclude that a thinner wall on an ingot mold carries away more heat during the solidification of the ingot than a thick wall; that the principal cause of ingot defects is the unsuitable design of the ingot molds, the crop-end being particularly disadvantageous; that an improvement can be effected by making the mold wall thicker at the top and by giving the mold none or only a minimum amount of taper.

AIK (1a)

Electric Steel Castings

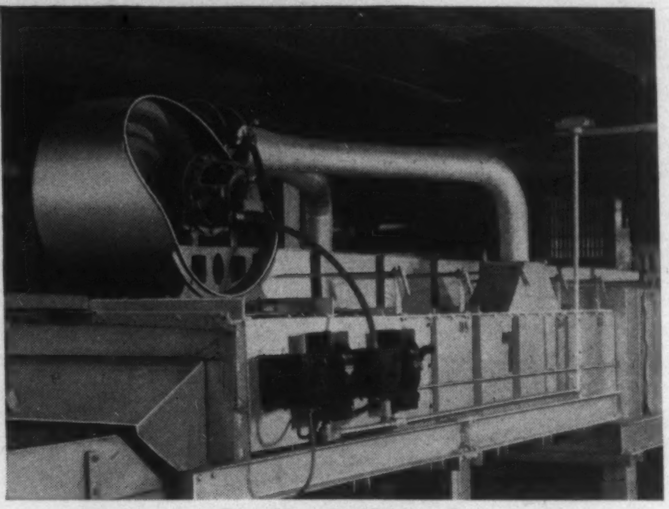
"A Little Knowledge is a Dangerous Thing." John Howe Hall. *Foundry*, Vol. 67, Sept. 1939, pp. 22-23; 69-70; Oct. 1939, pp. 31-32, 84-86; Nov. 1939, pp. 35, 86, 89. Practical discussion.

The first electric steel in this country was made in basic-lined furnaces. About 1923 foundries shifted from basic to acid methods, owing to the lower costs and higher output, less difficulty in keeping sticky slag out of molds and greater fluidity of metal associated with acid operations. Deoxidized basic steel, though of higher quality when carefully made presents greater production difficulties. In comparing open-hearth and acid electric steel, Melmoth states that open-hearth and electric steel



TIN PLATE
NORMALIZER

BAKING OVENS



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may be chemically identical, but not identical in constitution. This situation is caused by the non-metallics present in electric steel unless carefully produced. Such non-metallics are probably silica particles of ultramicroscopic nature.

Sims and Lilliequist showed that low ductility in cast electric steel was associated with certain arrangements of non-metallics, especially Mn sulphide. When Al was added the inclusions were globular and not harmful to ductility. A heat melted with 4 times the usual amount of iron ore gave sound tests with good ductility, even though Al was added to ladle, while a heat of clean scrap, melted under slag practically free from FeO, treated with ferrosilicon and ferromanganese in the furnace and a little Al in ladle, was so gassy and wild that no test bar could be obtained. Inclusions in all probability are held in solution in liquid steel and their shape and form depend upon how late in the period of solidification of the metal they come out of solution. High oxygen content decreases the solvent power of steel for non-metallics. To assist in retaining such helpful residual gas in solution, thorough deoxidation and minimum exposure after deoxidation are recommended. The cure for sporadic embrittlement due to small additions of Al, is more Al. Steels high in S are affected more than low S metal. Solution of Mn sulphide in steel is affected greatly by the oxygen content.

Successful electric furnace operation may be summarized as follows: (1) Use ore or scale with charge so proportioned as to melt fairly high in C, and boil vigorously. (2) With more ore if necessary, continue to boil until C is reduced to about 0.10%, Si to 0.05% and Mn to 0.08%. Allow boil to taper off at these figures. (3) Adjust C with low-Si pig iron or washed metal. (4) Build up the slag either by sand addition or by absorption from furnace bottom. (5) Deoxidize in the furnace with ferromanganese and ferrosilicon, when nearly ready to tap; and (6) add at least 0.075% Al (½ lb./ton) before slag starts to run.

Converter and open-hearth steels are subject to Al embrittlement. Introduction of the method of lowering S by treating the converter charge with fused soda ash, either in cupola in ladle or both, has largely eliminated that difficulty. Side-blow operation is a step-by-step process leading to vigorous boil and final flame that complete the process of conversion.

The recommended methods of securing low gas content in acid electric furnace steel are: (1) Long vigorous boils; (2) thorough oxidation; (3) low residual Si and Mn; (4) moderate metal temperature; (5) no increase in temperature after deoxidation; and (6) deoxidation late in the heat. When the converter is turned down ferrosilicon is charged to bath for deoxidation. The next precaution is the addition to the ladle of enough Al to completely deoxidize the metal and leave a considerable excess. VSP (1a)

Adding Alloys To Cast Iron

"A Note on the Effect of the Addition of Molybdenum, Tungsten and Titanium, Together with Calcium Silicide, to Cast Iron." J. E. Hurst. *Foundry Trade J.*, Vol. 61, Oct. 19, 1939, pp. 265-266, and 280. Original research.

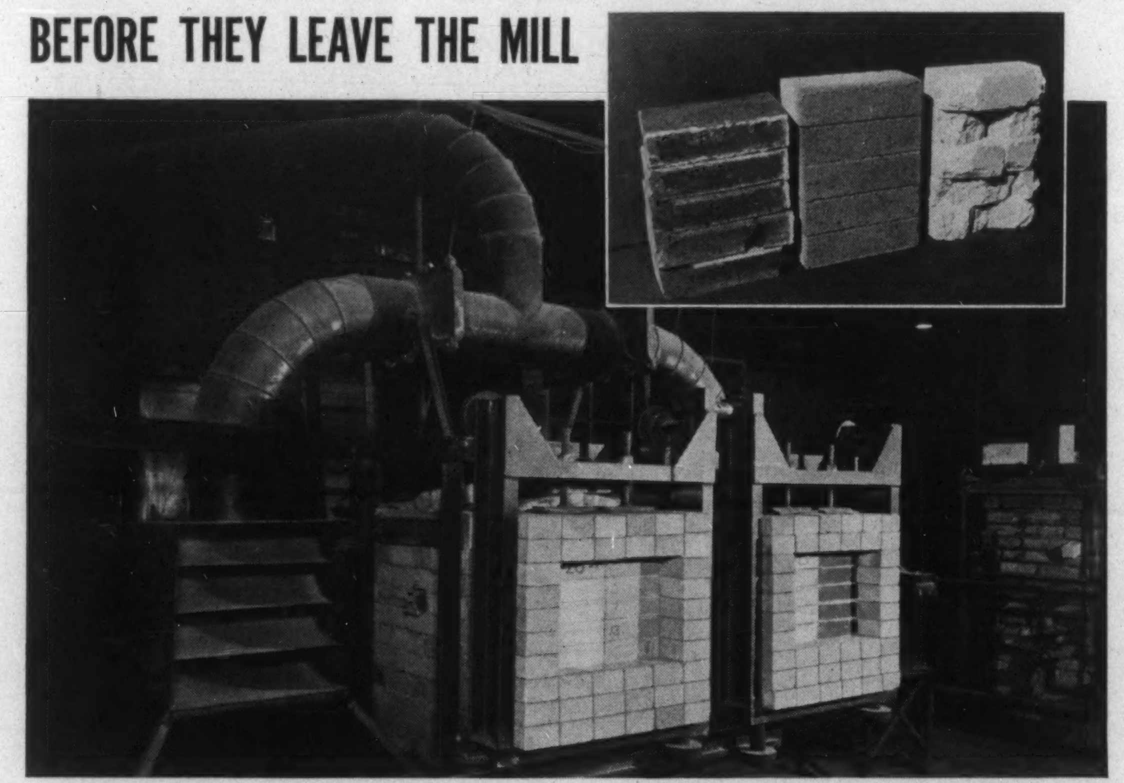
A method of making alloy additions by the use of an oxide of the alloying element in conjunction with a reducing agent is described. This method was explored since, in the case of W and especially of Ti, the yield of alloy metal is low when employing the ferro-alloy, partly because of the lower melting and pouring temperatures of cast iron. The reducing agent chosen was calcium silicide and the alloying additions were Mo, W and Ti. Intimate mixtures of powdered calcium silicide and the metallic oxide were used in the experiments, and a study was made of the yield of metallic alloy and of other changes in the composition of the metal, particularly in the Si content.

In the case of mixtures containing MoO_3, a vigorous reaction was observed in all cases except where the oxide was in the form of coarse particles. The yield of Mo from its oxide compared favorably with the yield obtained from powdered ferro-molybdenum. The very high breaking strength obtained by the addition of mixtures of CaSi and both molybdic oxide and ferromolybdenum are of special interest and importance. The yield of W from mixtures of WO_3 and CaSi was not so good as in the case of Mo.

In the case of addition of CaSi and TiO_2, very little reaction was observed. The yield of Ti in the molten metal was exceptionally low, as was also the yield of Si. In spite of this the joint additions had a noticeable effect in reducing the combined carbon content. In all the experiments, whether with Mo, Wo or Ti, there was a slight reduction in total carbon content associated with the addition of the powder. Perhaps the most important change in composition is that of S contents. In all cases there is a reduction. In the case of Mo additions the reduction is considerable, and its amount bears some relation to the Mo content. AIK (1a)

PROVED PERFORMANCE

BEFORE THEY LEAVE THE MILL



Test results in upper picture show graphically how effectively Armstrong's Brick (in center) resist spalling. In operation, the special test equipment shown in the large picture alternately heats and cools panels of brick 10 times in 10-minute cycles following a 24-hour preheat period.

Armstrong's Brick constantly undergo practical tests like this one for SPALLING RESISTANCE

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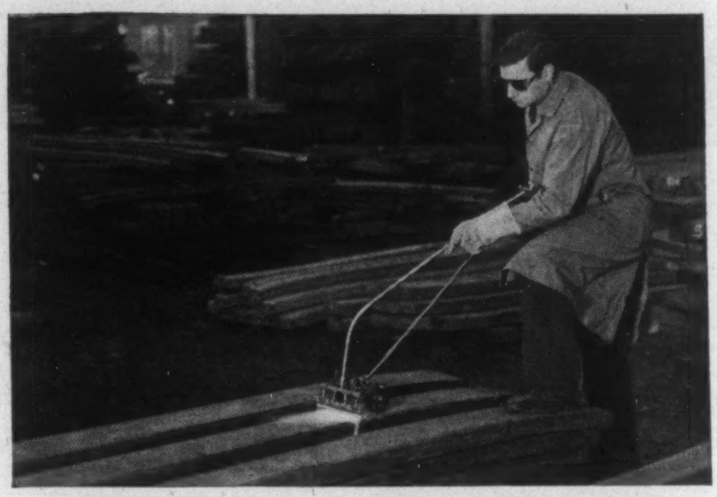


Flame-descaling billets with flat-tip assembly mounted on carriage.

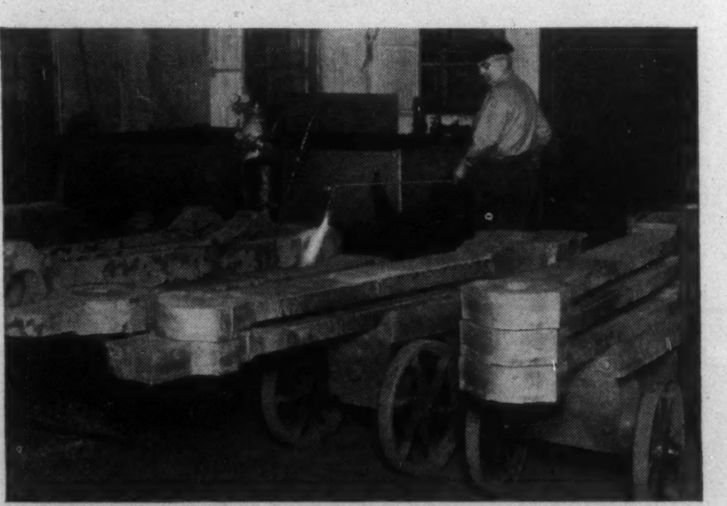
THE PROCESS IS ECONOMICAL

It may be conducted by ordinary labor in areas adjacent to other plant operations or machinery. There are no handling or rehandling costs. Defects, seams and fissures that may later cause difficulty and perhaps failure are exposed. A natural surface, free from discoloration, is secured.

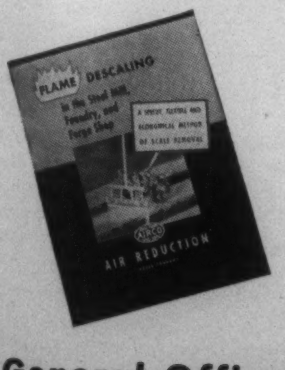
Flame-descaling a large casting with round tip mounted on extension.

THE PROCESS IS FLEXIBLE

Size or shape of object is no limitation. One hundred pounds to one hundred tons or larger objects may be flame-descaled. The apparatus employed is as flexible as a welding outfit—remote crevices and deep openings may be cleaned as well as flat surfaces.



Flame-descaling locomotive side and main rod forgings.



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1b. Non-Ferrous

Production of Tungsten

A Composite

The difference in extraction practice for tungsten necessitated by the difference in quality of concentrates is interestingly demonstrated by comparing two recent articles, one based on the use of high-grade concentrate, and the other on low.

A commercial method of producing tungsten powder by a company on the west coast is described by J. MURPHY ("Production of Tungsten Metal Powder," *Western Mach. & Steel World,* Vol. 30, Oct. 1939, pp. 318-319). Scheelite or wolframite with ¾-1% W is commercially profitable. The concentrate containing 60-77% WO_3 is ground very fine and digested in acid to give 99.5% WO_3, which is dried and calcined. The oxide is then reduced to W in a special gas-fired furnace using natural gas. In the furnace are a number of 4-in. Ni-Cr steel tubes with cross rods of the same material; welded onto the heat resisting tubes are lengths of ordinary steel pipe which form the cold zone. The brick floor is so designed as to prevent the flames from impinging on the tubes. The WO_3 is charged in special alloy trays which just fit into the tubes. After the charge is held in a hydrogen atmosphere at 1800°-1900° F. for 15 hrs., it is pushed into the cold zone and allowed to cool to room temperature before it is brought in contact with the air. A condenser removes the moisture from the hydrogen and recirculates the latter. The usual purity of the tungsten is 9.5%. Twenty ft.^{3} of gas are required for drying and reducing 1 lb. of WO_3.

Scheelite concentrates containing only 1/6 as much WO_3 as those described by Murphy are the raw material for an autoclave extraction process investigated on a laboratory and semi-commercial scale by I. N. MASLENITSKII ("Autoclave Process of Extraction of Tungsten from Concentrates," *Tsvetnye Metally,* No. 4-5, April-May 1939, pp. 140-143; in Russian). The scheelite concentrates contained about 10% WO_3. Preliminary tests were made using mixtures of scheelite ground to —200 mesh, and Na_2CO_3. It was found that at 200° C. and 15 atm. pressure the ratio $Na_2CO_3 : WO_3 = 3$ should be used in order to effect an almost complete (98%) decomposition of scheelite according to the formula $CaWO_4 + Na_2CO_3 \rightleftarrows Na_2WO_4 + CaCO_3$. Further tests showed that ore concentrates with various concentrations of scheelite require greater amounts of Na_2CO_3 than pure scheelite mixtures; for 90% decomposition of $CaWO_4$ the ratio should be from 3 to 4.5. On a semi-commercial scale 85% decomposition of $CaWO_4$ was obtained. Extraction of tungsten from solutions gave precipitates containing 50 to 68% WO_3. The work is being continued to establish the technique of the autoclave process on a fully commercial scale. X (1b)

Electrolytic Refining

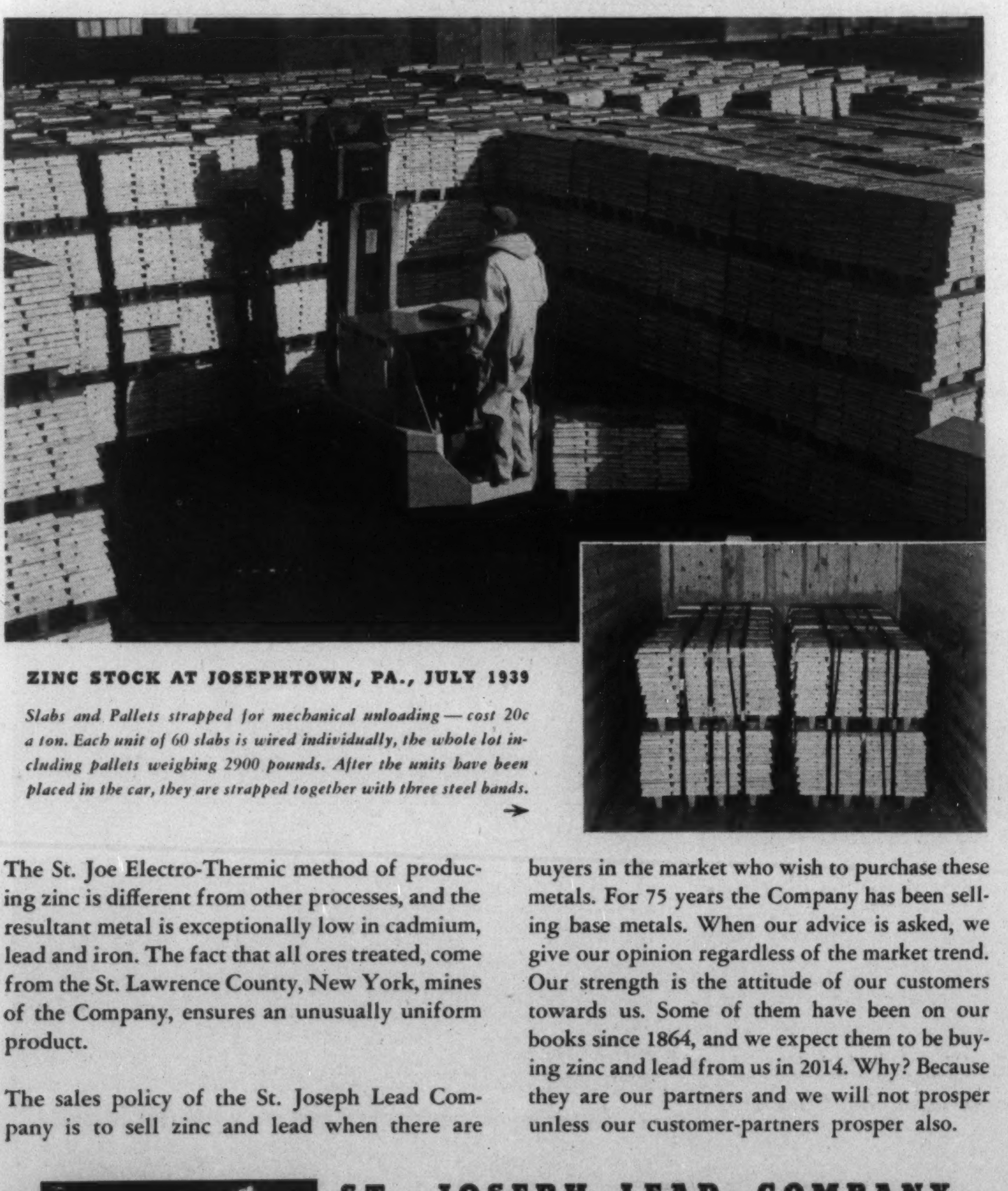
THE REFINING OF MOLTEN ALLOYS ("Die Raffination geschmolzener Legierungen") PAUL DROSSBACH. *Z. Elektrochem.* Vol. 45, July 1939, pp. 534-540. Original research.

A major requirement for the refining of molten (binary) alloys is a chemical equilibrium in which practically negligible quantities of the nobler metal go into solution during anodic polarization. Also, refining can be carried out only if the current density is selected according to the quantity of the less noble metal which is moved by diffusion; if a certain current density is exceeded the nobler metal, too, goes into solution. This current density can be determined mathematically. The most favorable operating conditions for successful refining (if, in the first place, it is thermodynamically possible) are, at the anode: Low current density, agitation of the alloy and electrolyte, low concentration of the salt of the less noble metal, and vapor formation of the less noble metal only; at the cathode: high current density, little or no agitation, high concentration of the salt of the less noble metal, vapor formation of the nobler metal, as it would thus go into solution from the cathode metal.

On the basis of these theoretical deductions refining experiments were carried out. From an alloy of 66% Fe, 18% Al, and 16% Si, aluminum of 99.94% purity could be produced. The current efficiency was 99.8%, the Al yield 94%. For commercial application the furnace design and construction must be such as to permit accurate control of current density.

The refining of a Pb-Zn alloy with only 10% Zn yielded at the cathode completely Pb-free Zn; the anode metal contained only 0.2% Zn. The end of the refining process is indicated by a sudden increase in the polarization voltage. The anode alloy was stirred continuously in order to insure uniform concentration throughout. Refining of a Sn-Zn alloy demonstrated the necessity for stirring to enable accurate control of the process. This need was not so great with light alloys, where probably the differences in specific gravity produce a stirring effect by lift.

All experiments demonstrated that if the process is controlled by measuring the polarization voltage, and if the proper cur-



FROM ORE TO METAL

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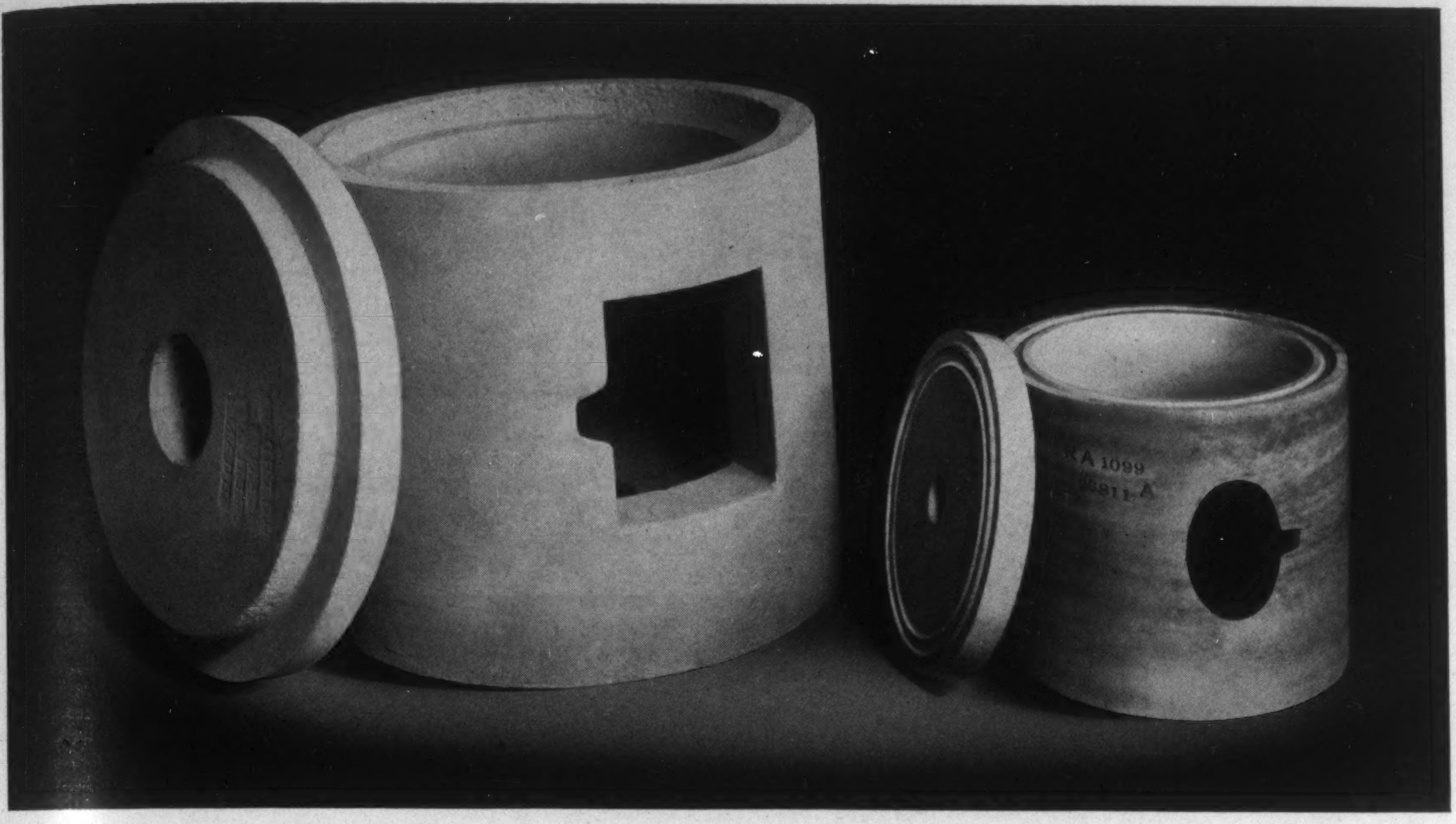

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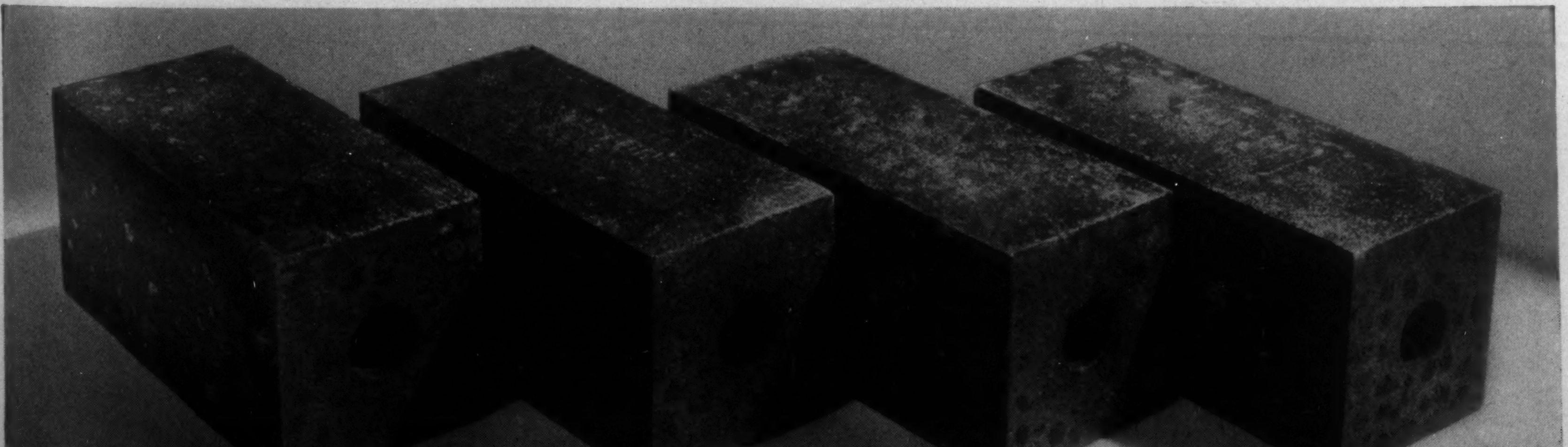


rent density is applied, it is possible to carry out almost quantitative refining. The process complies with technical requirements as far as material output and current efficiency are concerned. RPS (1b)

Heavy Phosphor-Bronze Castings

"PHOSPHOR-BRONZE CASTINGS OF HEAVY SECTIONS." A. HOPWOOD. *Foundry Trade J.*, Vol. 61, Oct. 26, 1939, pp. 285-287; Nov. 2, 1939, pp. 303-304. Practical investigation.

The failure of many castings to meet accepted standards with respect to Brinell hardness and density is often ascribed to unsuitable casting temperature and furnace practice, whereas the mold condition and material, coupled with the slow cooling consequent upon mass, can be responsible when using sand molds. A test was carried out with "green-sand" and "chill-cast" bars. Chill casting permits a greater latitude in casting temperature that can be used and still give a serviceable casting with fine grain, sound, even structure throughout the mass, good density and satisfactory Brinell hardness.

The loose open structure so prevalent in heavy-sectioned, sand-cast phosphor bronze castings is particularly dangerous in heavily-loaded bearing surfaces; the delta phosphide eutectic often appears in relatively large masses with small microscopic fissures leading off, resulting in a "loose" fracture. Slow cooling, due to large amounts of metal passing over one section and thus causing hot spots, will give the same results as will hot molds. Segregation (normal or inverse) of the last metal to solidify is responsible for internal and general openness of the structure. Owing to the low heat conductivity of the sand, the rate of cooling will be relatively slow after the first deposition of solid metal, even with very low casting temperature.

The speed with which the dendrites build up into the interior of the casting depends on the size of section. The slower the rate of cooling, the more will the dendrites spread into the section having still-liquid metal around them. Near the outer edge, diffusion takes place, leading to large dendritic growth and virtually isolated pools of still-liquid metal. The ideal condition is that the casting should commence to solidify from the bottom upwards, the risers or feeders remaining liquid to the last. AIK (1b)

Crucible Furnaces for Light Metals

RESISTANCE-HEATED ELECTRIC CRUCIBLE FURNACES FOR LIGHT METALS ("Widerstands-beheizte elektrische Tiegelöfen für Leichtmetall") O. GENGENBACH. *Elektrowärme*, Vol. 9, Nov. 1939, pp. 227-234. Descriptive.

Furnace types for melting small amounts of aluminum and magnesium are reviewed, and resistance-heated crucibles discussed in particular. Graphite crucibles have the great advantage of not contaminating the melt. On the other hand, their heat conductivity is rather low, so that the heating elements (when outside) must burn at 1050-1100° C. to give a crucible temperature of about 900° C.; this reduces the life of the heating elements. Also, the graphite itself burns away if the inner wall is not covered by the melt.

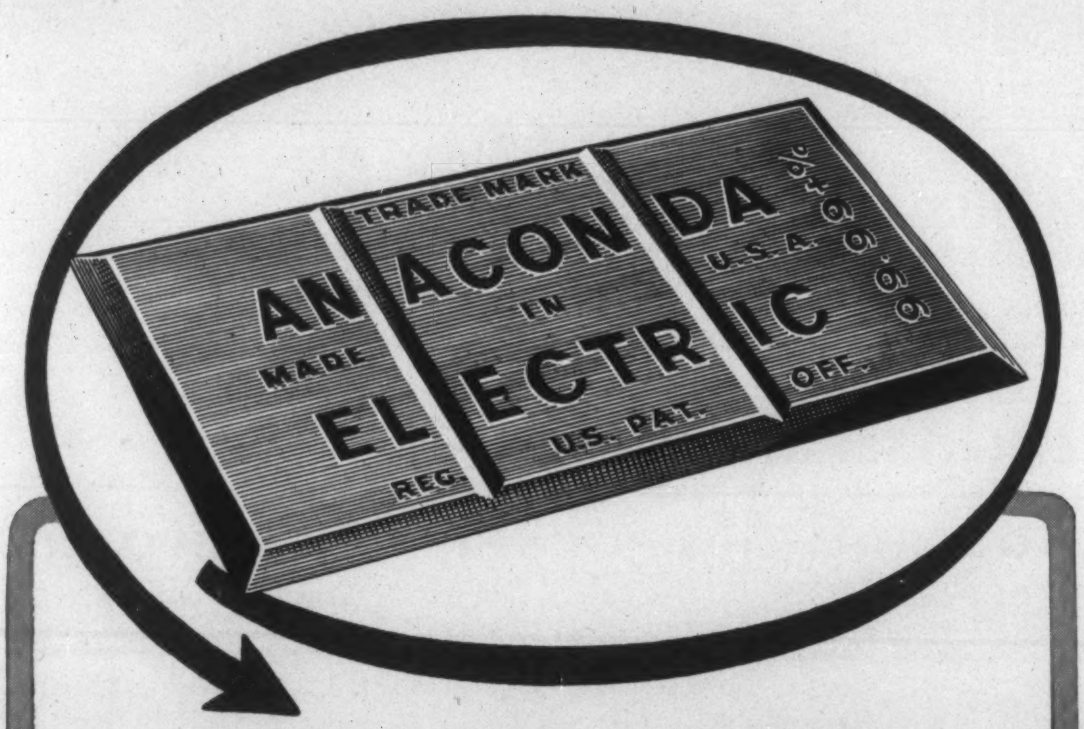
Cast iron crucibles, sometimes with low chromium content, are very satisfactory if often cleaned; molten aluminum dissolves iron and the latter is decidedly injurious to the aluminum. As molten magnesium does not dissolve iron, cast iron crucibles are well suited for melting magnesium. Care must be taken, however, that the scale (oxide) which forms on the outside of the crucible does not come in contact with the liquid metal, as the mixture burns explosively. Ha (1b)

Defects in Non-ferrous Ingots

"DEFECTS IN NON-FERROUS INGOTS." G. W. BAILEY. *J. Birmingham Met. Soc.*, Vol. 19, June 1939, pp. 64-82. Comprehensive survey. Includes discussion.

Among surface defects, oxide folds may be prevented by pouring in such atmospheres that oxides do not form. In aluminum bronzes, they may be minimized by additions of phosphorus. Laps and splashes are reduced by fast pouring at high temperatures. Blowing and mold defects are often the result of a reaction between the carbon of the cast iron molds and surface oxide, and can be prevented by suitable mold dressings or the use of copper-faced molds. Inverse segregation is sometimes troublesome in aluminum alloys containing a low-melting constituent.

Among internal defects are evolved gases, entrapped gases, shrinkage cavities, and non-metallic inclusions. Considerable attention has recently been given to the use of oxidizing conditions for melting copper alloys in order to remove reducing gases. Entrapped gases may be caused by volatile mold dressings or turbulent pouring. Special methods for producing sound ingots include the Durville process, the Erichsen horizontal water-cooled-mold, and the Roth slit mold. In the Roth mold the metal is poured through a slit so that the pouring spout is close to the bottom of the mold. As pouring continues, the mold is lowered and the slit closed. JCC (1b)



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Stresses in Welds

"Shrinkage and Other Initial Stresses in Welds." M. F. Sayre. *Welding J., N. Y.*, Vol. 18, Nov. 1939, Supplement pp. 393-397. Survey.

Five types are listed: (1) Cracks that occur while the metal is still at a red or white heat. (2) Cracks occurring below the transformation temperature and within the blue-brittle range or secondary-brittleness range of the material. These cracks run either at right angles to the weld or along the length of the weld. (3) Cracks due to martensite formation. These are mainly of two forms (a) minute intergranular cracks extending transversely across individual martensite needles and (b) quenching cracks, which are intercrystalline, following austenite grain boundaries through or in the immediate vicinity of martensite areas. (4) Failures resulting from the geometry of the pieces being welded, or of the weld itself. (5) A rare type of failure occurring some time after welding and resulting from the combination of live load stresses with entrapped stresses or from the entrapped stresses alone.

The theory of crack formation is discussed at length from a consideration of the margin between the cohesive and flow strengths of materials and the variation of shearing stresses under multi-axial tensional stresses. The relaxation of entrapped stresses with time in service is shown to be possible through creep and plastic flow. The after-effect from entrapped stresses under various service conditions of static, fatigue and impact loading, for multi-axial stresses and when subject to corrosion are considered to range from minor to major importance depending upon magnitude and nature of the stress.

The use of stress-relieving heat treatment is shown to be inadequate when cracks of considerable size have occurred. The remedy is a change in welding technique. It is recommended for future work that the extent of relaxation of entrapped stresses with time and the effect of the stresses on resistance to fatigue be determined. Failures during fabrication are listed for future investigation by means of notch impact tests on specimens of varied width. WB (2)

Resistance Welding Precision Assemblies

"Resistance Welding in the Manufacture of Precision Assemblies." F. D. Rogers (International Business Machines Corp.) *Ind. & Welding*, Vol. 12, Oct. 1939, pp. 52-56; Nov. 1939, pp. 39-42. Practical discussion.

The general acceptance of resistance welding as an effective method of joining parts for use in business and accounting machines must depend upon the merit of the process itself. Such merit can be demonstrated only by the constant regularity with which parts continue to perform their functions regardless of how many adverse factors may be present in the processing, any or all of which are potential sources of difficulty. Of the several hundred different resistance-welded items in lots of from 5 to 10,000 pieces, a majority are planned around projections in one of various forms, using butt welding and a liberal sprinkling of spot welding. Tolerance is often limited to 0.0005 in.

In all of these operations strictest attention is given to the planning, tooling and set-up stages of the many parts. Where projections are required a standard of sizes is established so that an ordinarily good selection can be made the first time by the draftsman. It is found that for mild steel of 0.025 to 0.203 in. thickness, height of projection of 0.004 to 0.015 in. and a dia. of 1/16 to 7/32 in. were suitable. Projections can be developed with greater individual spot strength; however, the added strength results in greater distortion, more tool maintenance and a sacrifice in dimensional accuracy of assembly.

For maximum uniformity, the surface condition must be exceptionally good. Washing in carbon tetrachloride alone, or followed by dry sawdust tumble, will usually suffice for small parts on which this can be done. Weld attachment of braided electrical wire ends to terminal clips is serviceable. CEJ (2)

Repairing Mill Shafts

"Repairs to Mill Shafts." Edward Ingham. *Iron & Steel*, Vol. 12, Sept. 1939, pp. 723-724. Practical.

Electrodeposition and metal spraying are used in building up worn or weak shafts, while welding can be very advantageously used for building-up and filling-in damaged keyways, and repairing cracked and broken shafts. The shrinking of a socket upon a carefully prepared spigot as a method of repairing broken units is deprecated as is the method of screwing one piece into another. Even when carefully keyed such methods have never been found satisfactory on the continent.

A valuable feature of electrodeposition is that it entails no heat treatment, and in the case of nickel can be laid one-half inch thick. The surface layer is machined to the desired finish. After reboring wheels, shafts can be increased in diameter to accommodate the new dimension, obviating the necessity of buying a new shaft. Units weighing 8 to 9 tons have been so handled.

Welding must be used for repairing cracked parts because normally the surfaces cannot be satisfactorily cleaned and nickel cannot be properly "thrown" from the electroplating bath to form an intimate bond at the base of deep cracks. Welded units are fully as strong as the original if the work is properly done; most failures in welding result from improper technique or insufficient equipment. The greatest care and attention should be given such features as choice of welding rod, selection of proper current to insure complete fusion, skill of the operator, proper cleaning of surfaces, and adequate veeing out of the metal. Where these factors are overlooked the results are apt to prove unsatisfactory.

Damage by the welding heat and locked up stresses can be corrected by careful heat treatment. Another important feature is careful alignment of the shaft after repair. Successful applications of welding on difficult jobs are discussed. HFT (2)

2a. Ferrous

Welded Pressure Piping

Experience with Welded, Radiographed Pressure Piping and Their Factors of Safety ("Erfahrungen mit röntgen - durchstrahlten, geschweissten Druckleitungen und deren festigkeitstechnische Sicherheit") M. Ros & E. Brandenberger. *Eidgenossische Materials—und Versuchsanstalt, Zurich.* Bull. No. 122, 1939, 26 pp.

Experiments in the welding of and tests on welded pressure piping of large diameter and on some pressure vessels lead the authors to certain summarized conclusions and recommendations. The experiments through which the conclusions were reached are not given in detail, though copious illustrations give an inkling of their type.

The endurance range (repeated stress in tension from zero to a maximum at which the specimen will withstand a million cycles) is the important mechanical property most affected by welding. Factors of safety of properly welded and inspected tubes that were examined were 3 to 3.6 on the basis of static strength, 1.8 to 2.2 on the basis of yield strength, and 1.6 on the basis of endurance. The endurance of welds drops from a mean of 22,500 lbs./in.^{2} for normal welding to one of 16,000 for overhead welding. By special precautions and proper qualification of welders, the endurance can be brought up above 25,500 lbs./in.^{2}, and this is the minimum for "first grade" products.

Smoothing and polishing the weld raises the endurance 30%. Craters at the ends of the weld are especially to be avoided. With steel of not over 0.15% C, with 51,000-62,500 lbs./in.^{2} tensile strength, the welds should show, when tested perpendicular to the weld, a tensile strength within that same range. The welds must show no cracks. Surface hardness is to be not over 200 Brinell, interior hardness 115-170 Brinell; other requirements (minimum) are 19,400 endurance (if overhead welded, 15,000 lbs./in.^{2}), 24 to 34 repeated bends on plate thinner than 0.472 in., 19 to 24 on sheet 0.472-0.787 in. and 14-19 on thicker plate.

Tubes that have been bent so that an extreme fiber has elongated more than 1% are to be annealed at 1150° F. for 2 hrs. With steel of 60,000-68,000 lbs./in.^{2} tensile strength, annealing above the critical, and slow cooling, are specified. The endurance of welded specimens of the stronger class of steel is only some 10% above that of the softer class. HWG (2a)

Welding Tungsten Steels

"WELDING TUNGSTEN STEELS—A REVIEW OF LITERATURE TO JULY 1, 1937." W. SPRARAGEN & G. E. CLAUSSEN. *Welding J., N. Y.*, Vol. 18, Nov. 1939. Supplement pp. 430-435. Excellent summary. 83 references.

Welding Plain Tungsten Steels. Practically no tungsten is lost in passing through the arc in welding. The manual or automatic flash welding of a tool steel containing 0.99% C and 0.76% W presented no difficulties. The critical cooling velocity of the steel determines whether martensite will appear. The higher the welding temperature, rate of cooling, and carbon and alloy content, the greater will be the amount of retained austenite. If the alloy steel is welded to a plain carbon steel, the alloy steel may harden but the plain carbon steel may consist of sorbite or pearlite in the heat-affected zone. The oxygen cutting of tungsten steels is not difficult, if the tungsten content is not above 10% with or without 5% chromium at 0.8% carbon. Steel with 17% tungsten can be oxygen-cut only if it is preheated and the oxygen pressure is increased. Steel with over 20% tungsten cannot be oxygen-cut even with preheat.

Welding Tungsten High Speed Steel. The chief application of resistance butt welding to high speed steel is the welding of high speed steel tips to plain carbon or alloy steel shanks in the preparation of lathe and other tools. The butt-welded tools perform as well in service as tools forged entirely from high speed steel. High speed steel requires more heat than mild steel to reach the welding temperature. In addition, high speed steel has a high electric resistivity. Consequently the high speed steel should project further from the grips. The upset on both sides of the weld must be uniform. The tool may be annealed after welding or may be heat-treated immediately after welding and without cooling in order to prevent cracking of the high speed steel. A resistance-welded 18-4-1 high speed steel (0.60% C, 0.25 Si, 0.25-0.35 Mn, 17-18 W, 3.75-4.25 Cr, 0.90-1.10 V) had a tensile strength of 104,000 to 123,000 lbs./in.^{2}; the unwelded steel had a tensile strength of 115,000 lbs./in.^{2}.

The chief difficulty in the oxyacetylene welding of high speed steel is cracking, to avoid which the steel must be preheated bright red. For arc welding, one authority recommends preheating to 200°-400° F. The arc-welded beads are woven the full width of the surface to be built up. The finished tool should be reheated (2 hr. per in. at 1000° F. and cooled in still air after welding for maximum hardness and toughness. If high speed steel is applied to high-sulphur free-machining steel the deposit will be porous. Deposits on low-sulphur steel are not porous. In the atomic hydrogen welding of tool steels containing 0.7% C, 0.24 Si, 0.2 Mn, 5 Cr, and 22 W, good results have been obtained by first annealing the steel at 1550° F., then preheating it to 1450°-1650° F., and welding it with a rod of the same composition.

Another joining process consists of inserting a strip of copper between the mild steel and high speed. The joint is heated to hardening temperature, about 2200° F., in a reducing atmosphere. A strip of brazing metal or copper 0.04 in. thick with or without borax need simply be placed between the parts which are held together by wire. Copper- or bronze-welded high speed steel cannot, of course, be heat treated. In forge welding the bright high speed surface is coated with borax and brought to a white heat; a mixture of borax and iron filings is sprinkled over the surface, after which the iron shank is hammer-welded to the high speed.

Welding Low - Chromium - Tungsten Steels. Low-chromium-tungsten steels are widely used as filler rods for hard facing by arc or oxyacetylene processes. The hardness of the deposit may be 435 to 580 Brinell. To obtain good penetration in welding, the electrode should have a higher melting point than the base metal. The reverse is true in surfacing, for which a bare electrode operated on the positive

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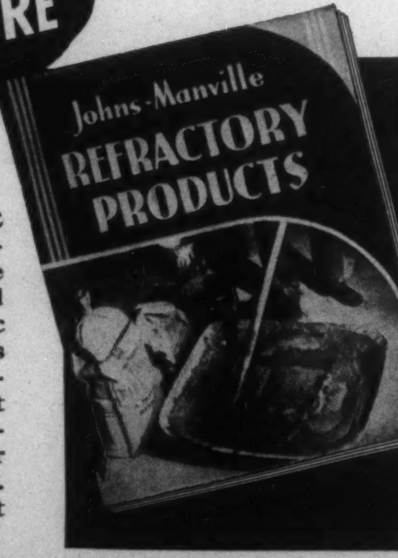

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pole and containing 1.10% C, 0.30 Mn, 0.20 Si, 1.5 W, and 1.0 Cr was found to be best. Deposited on rails, the weld metal hardens to 500 Brinell, but is brittle. For building-up rail ends of a wide variety of compositions by the oxyacetylene process, some authors favored a rod containing 1.2% C, 0.9 Cr, 1.7 W, 0.2 Mn, and 0.12 Si. A reducing flame was better than neutral because there was less danger of overheating. WB (2a)

Mild Steel Wire Electrodes

"FACTORS GOVERNING THE ARC WELDING BEHAVIOR OF MILD STEEL WIRE." J. C. JOUBLANC. *Wire & Wire Products,* Vol. 14, Dec. 1939, pp. 697-698. Progress report.

The behavior of mild steel wire when used for arc welding electrodes was investigated. The source of the wire (*i.e.* type and amount of scrap used in its production), chemical composition, and method of wire drawing have a powerful effect on the performance of the wire as an electrode. Tests showed that softer wires welded with much less arc disturbance than harder ones; wire given 2 finishing passes after annealing was found to be ideal from the dual standpoints of cutting the wire into suitable lengths and of welding behavior. A stable arc, *i.e.* one that does not fan out more than about ¼ in., is obtained with a wire of inherently good welding quality, or one to which a stabilizing substance, *e.g.* titanium, has been added.

Sulphur in the wire is always a cause of sputtering. Although phosphorus and copper are generally considered to be injurious to good welding, a wire with 0.15% P gave welds with increased tensile strength when added as ferro-phosphorus through the coating. Copper, also, even up to 1%, added through the coating did not harm the welding quality of a low-carbon base wire.

A most important factor affecting the welding quality of mild steel was, however, found in the surface tension of the molten metal as it is transferred across the arc; this property influences both the shape of the deposited bead and the melting rate of the electrode. A wire with a high surface tension in the molten state transports the metal across the arc in large globules; increased spattering occurs with larger globule size, due very likely to oxide inclusions, inside the globules, that explode in reacting with carbon. A thin coating of a suspension of antimony in sodium silicate decreases surface tension considerably, resulting in rapid transfer of small globules across the arc, which is thereby also increased in stability.

The carbon-manganese ratio is also of importance; the best welding performance and properties are apparently obtained with 0.06-0.10% C to insure proper ductility, and with over 0.50% Mn for proper deoxidation and increase of tensile strength. A good method to use in producing such wire is to bring down the carbon as low as possible by deoxidizing the bath with aluminum just before high-carbon ferromanganese is added. This permits of greater manganese recovery and therefore economy in the use of ferromanganese. Ha (2a)

Electro-tinplating of Strip Steel

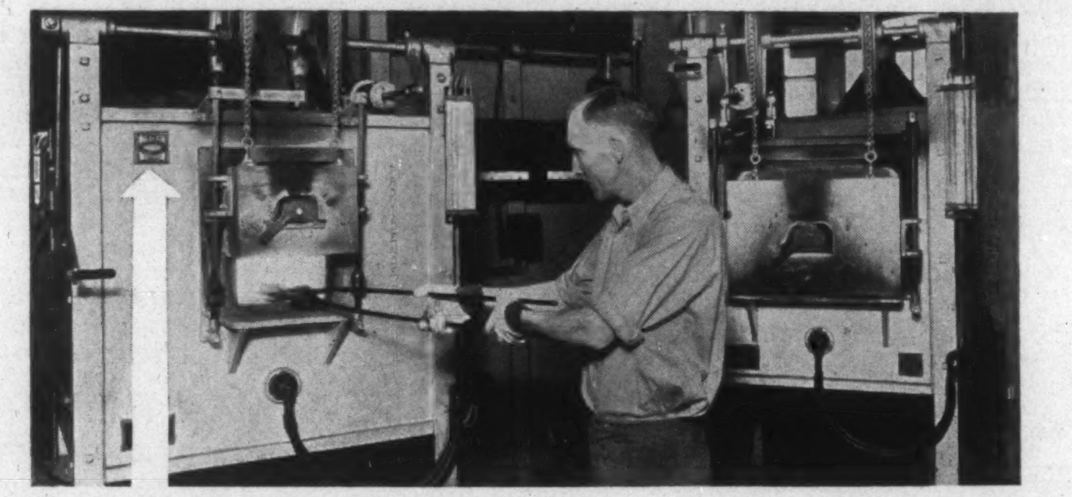
"DEVELOPMENTS IN ELECTRO-TINPLATING OF STRIP STEEL". D. C. BAKEWELL (Blaw-Knox Co.) *Iron & Steel Engr.,* Vol. 16, Dec. 1939, pp. 37-43; with discussion. Review.

Since 1927, when the world's first unit for continuous electrogalvanizing of wide strip was installed, several similar units for the electroplating of copper, tin, cadmium and nickel on steel strip have been built and operated. For all these, the operating "bugs" were eliminated very quickly, with the exception of tinplating.

With tin, the main difficulties were that the coating was too soft for satisfactory drawing operations, and that the product had a dull matte finish instead of the ordinary bright tin surface. Rotary scratch-brushing, applied to improve the lustre, increased the porosity, caused a substantial loss of tin (electro-tinned coatings are about 0.00005 in. thick) and failed to harden the coating. A better practice, now being commercially employed by two American companies, is to pass the electro-tinned strip through a hot oil bath at a temperature high enough to melt the tin, and following this by a quick quench in cold oil.

The present American practice is to use an acid bath, which has 3 outstanding advantages over alkaline-bath practice — no heating is required, a lower voltage may be used, and the speed of deposition is more than double for the same cathode current density. With a suitable electrolyte, the use of soluble anodes gives higher tin recovery than the insoluble. A suitable electrolyte will be free from sludge on continuous operation, will operate efficiently at current densities up to 300 amp./ft.^{2}, will not polarize or passivate the anodes during operation, and should operate at practically 100% current efficiency (either electrode) even at high current densities. Fluoride baths meet all these requirements, whereas sulphate baths do not.

"The eventual use of electro-tinplating in place of the present hot dip method seems to be inevitable." Electrolytic practice gives better quality (as shown by hydro-



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gen-evolution test) with thinner coatings, less porosity for equivalent coatings, better uniformity, cleaner edges, and, most important, reduced amount of tin required for equivalent results. This means not only lower raw material costs for tin, but reduced inventory charges.

Continuous operation is said to offer the maximum economy. In such practice the strip steel passes successively through an automatic seam welder, a slack-producer, a special cleaning-and-blue-oxidizing bath, a pickling bath, rotating scrubbers, the tinplating tank, a washer, a drier, a warm-oil bath, the hot-oil bath above the melting point of tin, a cold-oil bath, a solvent cleaner, washer, drier and a flattening and cutting machine.

Electrolytic tinplate has been produced experimentally with an undercoating of pure iron and of iron-nickel alloys. Very little tin is required for the outer coating, and the product is practically free from porosity.

Discussion brought out that the "special cleaning-and-blue-oxidizing" treatment mentioned above consists of passing the strip as anode through a "hot alkali electrolytic bath". The treatment is conceded to be not indispensable, but does give less porosity and a smoother coating than when pickling alone is used for cleaning. The blue-oxide process is also a "surface-quality-leveler," in that it vitiates surface non-uniformities between different heats, grades or sources of steel strip. (2a)

Welding and Hard-facing Severe Service Valves

"WELDING IN THE MANUFACTURE OF VALVES FOR HIGH PRESSURES AND TEMPERATURES". W. F. CRAWFORD & L. H. CARR (Edward Valve & Mfg. Co.) *Welding J., N. Y.*, Vol. 18, Nov. 1939, pp. 713-722. Practical.

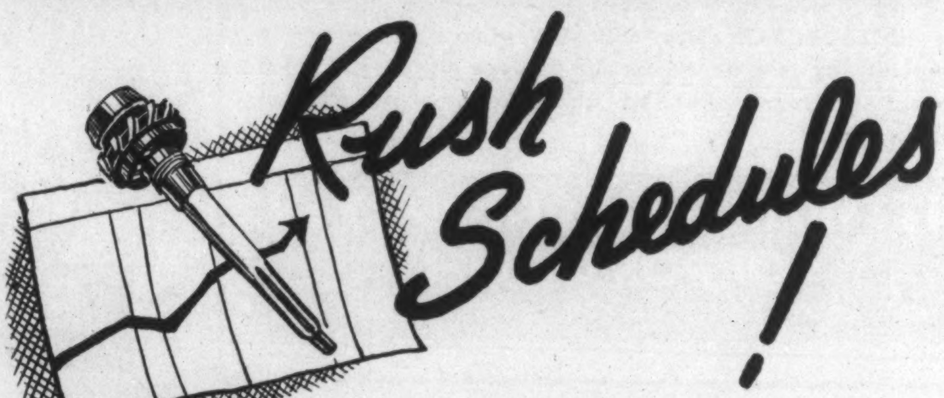
A thorough presentation is given of some welding problems that were reduced to a successful industrial application by means of analysis of service conditions and research on materials. The more widely-used valve steels and their properties are listed, and properties of carbon-molybdenum steels in cast and forged forms and of the weld deposit are tabulated.

A simple test is made to determine electrode characteristics and hardening effects in a 4x4x6-in. billet of carbon-molybdenum steel by depositing weld metal into a deep, drilled hole, and determining hardness. The test is considered satisfactory for indicating tendency for crack formation caused by air hardening characteristics and weld shrinkage as also for the ability of the welding operator. Average values for a valve body of carbon-molybdenum steel are (a) 180-310 Brinell for single pass weld, no preheat; (b) 180-250 Brinell for single pass with 400° F. preheat; (c) 150-223 Brinell for multiple pass, with no preheat; (d) 140-200 Brinell for multiple pass with 400° F. preheat. The valves are thoroughly normalized after welding.

Hard surfacing is applied to seats and disks of valves, the hard surfacing being applied either with the oxyacetylene torch or by metallic arc. Stellite deposits are used for valve seats. Other deposits containing chromium, boron or tungsten, which can be deposited with the metallic arc, are most successful where surfaces require exceptionally fine polished finishes. Flame hardening can be advantageously used for surfaces subject to wear when valve operating temperatures do not exceed 650° F.

A number of tests are reported on deposits of cobalt-chromium-tungsten alloy at 70° F. and 1000° F. to determine the relative tensile and tension and rotating beam fatigue properties for the alloy deposit, base metal and bond. The conclusions are that the bimetallic material can be expected to withstand the ordinary loads encountered in engineering service without any cumulative ill effects due to repeated stressing. There is no tendency for the hard-surface deposit to spall, and there is present a high strength bond with the base metal. Tests have also been made of the effect of temperatures up to 1100° F. on the hardness of deposited hard-surfacing material and commonly used valve body steels, which are shown in curves. Temperatures as high as 1000° F. have practically no effect on the hardness of cobalt-chromium-tungsten alloy even over prolonged periods of time.

The author's opinion is that application of hardfacing in several individual layers is undesirable for the oxyacetylene method of application, since this would mean a very thick deposit of a material which exhibits low elongation and reduction of area. A single, well-deposited oxyacetylene layer of cobalt-chromium-tungsten seems to represent good hard surfacing procedure. The expansion of the base metal during cooling through its critical points sometimes gives trouble because of the stresses set up in the alloy deposit, which does not go through the same expansion and contraction cycle in welding. The remedy was found in the selection of a base metal with suitable expansion characteristics and the use of preheat at a temperature slightly below the critical range so that it will not cool too rapidly immediately after each drop of alloy is deposited; the section is thereafter slowly cooled, and the hazard of cracked deposits is reduced. WB (2a)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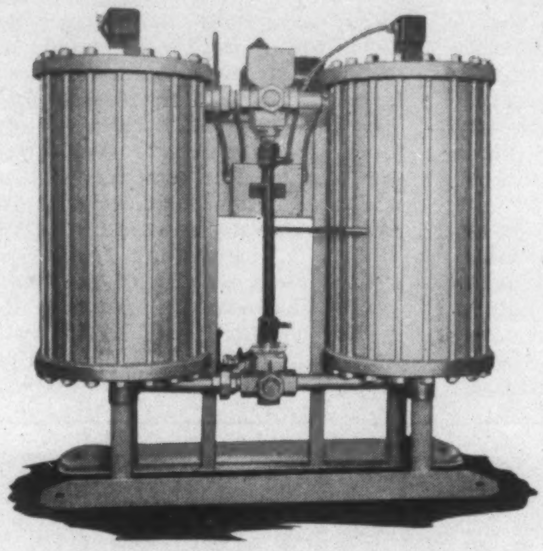

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A.C.S. MONOGRAPH
No. 79

By R. M. BURNS *and* A. E. SCHUH

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Flame Hardening

A Composite

Recent American advances in flame hardening—particularly the development of more fool proof, economical and automatic equipment—have been truly imposing. Nor has interest abroad lagged in this increasingly useful industrial art, as is evidenced by 2 recent articles in a German magazine—one giving directions for "line-hardening" technique, and the other reporting on thermal factors in the use of city gas-oxygen flames as well as the customary oxy-acetylene.

"Line-hardening" is the familiar technique in which the burner (usually multiple-flame) moves rapidly over the surface to leave a high-quenching-temperature line under the flame points, along which the quenching liquid follows immediately. Correct procedure for line-hardening [called in America "straight line progressive flame hardening"] is described by K. MEILLER ("Richtlinien für die Durchführung der Linienhartung", *Autogene Metallbearbeit.*, Vol. 32, Nov. 1, 1939, pp. 311-313). Case-hardening steels should not be flame hardened because of their too-low carbon content. More hardenable steels, gray iron and malleable iron are suitable materials.

To obtain satisfactory hardening, the material must of course be heated above the critical range, and the cone of the flame rather than its outer parts must do the heating. The most favorable heating time is obtained if the points of the inner flame cones are directly above the surface to be hardened, with the points of the flame cones about 1 mm. distant from the stock; this distance can be even shorter and still give good utilization of the flame. The cooling and quenching water supply must be carefully controlled so as not to disturb the heating effect of the flame; the water must flow steadily without splashing, and the quantity must be large enough for a sure quenching effect. The speed of motion of the flame should be 6-8 in./min. for a neutral flame, and can be increased to about 12 in./min. for an oxidizing flame. The burner should have an inclination of 10-15 degrees from the normal to the workpiece. The quenching spray should be parallel to the burners, and about 1.2 to 1.6 in. behind. It is recommended to determine, by trial or test, exactly the best conditions for each case.

A study of the types of flames that can be used in flame hardening by the straight-line and by the rotary progressive methods is reported by E. ZORN (Wärmeleistung von Azetylen-Sauerstoff- und Leuchtgas-Sauerstoff-Flammen beim Autogenhärten", *Autogene Metallbearbeit.*, Vol. 32, Nov. 15, 1939, pp. 321-327; Dec. 1, 1939, pp. 333-338). All the tests showed that best heat capacities are not obtained with neutral flames. By adjusting the flame to give an excess of oxygen, a greater depth of hardness could be obtained for the same speed of motion of the burner and the same heating time; or for the same depth of hardness, the speed of motion could be increased or the heating time shortened.

The best mixing ratios were found for oxygen/acetylene to be 3/2 and for the oxygen/city gas to be 2/3. The excess of oxygen had no detrimental effect on the marginal zones of the samples. If in rotary flame hardening two flames 180° apart were employed, the same hardening results could be obtained with about 1/3 less gas in both acetylene and city gas mixtures. The costs for both straight line and rotary hardening were approximately the same for the same hardness and depth of hardness.

No appreciable difference in structure was found between surfaces hardened by acetylene and by city gas flames. The marginal zone showed a very fine grain for lower heat supply and longer heating time; for higher heat supply and shorter heating time the structure was somewhat coarser but could still be considered as fine-grained. The hotter oxyacetylene flame did not produce a coarser structure than the less hot city gas-oxygen flame. Ha (2a)

Machining Steel with Carbide Tools

"NEW DEVELOPMENTS IN MACHINING STEEL WITH HIGH CARBIDE TOOLS." P. M. MCKENNA (McKenna Metals Co.) *Modern Machine Shop*, Vol. 12, Dec. 1939, pp. 60-68. Descriptive.

Tools made from tungsten-titanium carbide ($WTiC_2$) are very suitable for machining materials that produce a crumbly chip, like cast iron and brass. Such tools have high hardness and high thermal conductivity (about 3 times that of steel) so that materials with very low heat conductivity (*e.g.* bakelite) can also readily be cut. The tungsten-titanium carbide has a Rockwell hardness of 91A and a transverse tensile strength of about 240,000 lbs./in.^{2}.

The new material is used for cutting and machining gear blanks of Ni alloy steel, automotive axles after heat-treating, and projectiles of heat-treated S.A.E. 1045 steel; for roughing and accurately finishing stainless steel cylinders, cast steel truck wheels, laminated silicon steel motor cores, Hadfield's manganese steel, and hardenable Monel metal. Cutters tipped with the new material are said to cut 4-6 times as fast as high-speed steel cutters. Ha (2a)

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A. C. S. Monograph No. 71

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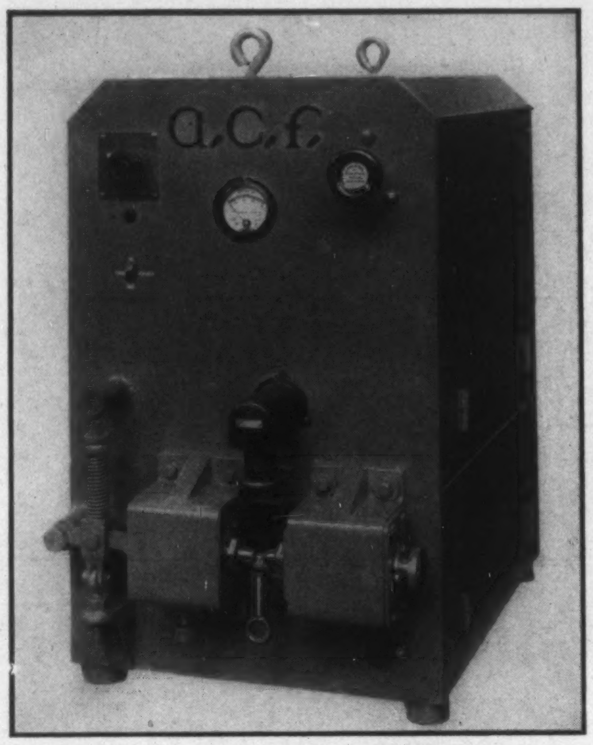

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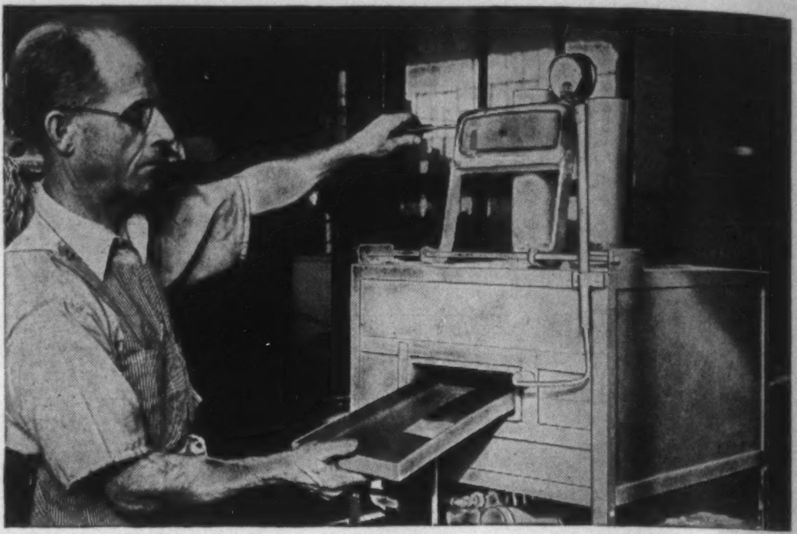

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Hot Galvanizing

A Composite

Hot galvanizing is the oldest and still the most widely used method of applying zinc coatings to steel. The process is also said to account for over half of the world's consumption of metallic zinc in all its forms. Hot galvanizing is overwhelmingly favored as the galvanizing method for steel sheet, although the evident advantages of electrogalvanizing for other forms of steel have led to the encroachment of the electrolytic process in many fields once held sacred to hot-dip.

The greater corrosion protection afforded by the thicker coatings possible by hot galvanizing has been an important factor in its continued successful application. Two recent articles discuss the properties and structure of the "alloy layers" characteristic of hot galvanizing, a third describes gas-fired galvanizing equipment as used commercially for large-scale production of such coatings, and a fourth describes the practice used by one galvanizer in finishing steel window sash.

Of the world's annual production of 1.5 million tons of zinc, about 900,000 tons are used for galvanizing and 90% of the latter for hot galvanizing—according to W. THALEMANN ("Eigenschaften der Feuerverzinkung - Gestaltung zu versinkender Werkstücke", *Oberflächentech.*, Vol. 16, Oct. 17, 1939, pp. 193-195; Nov. 7, 1939, pp. 199-202; Nov. 21, 1939, pp. 209-210). The three processes most widely applied are "wet-galvanizing", in which the articles are transferred while still wet to the zinc bath immediately after pickling and rinsing; "dry-galvanizing," in which the work is first treated and dried before being placed in the bath—a procedure by which highly bright surfaces are said to be produced; and "patenting-galvanizing", in which the bath is largely lead or lead-manganese alloy with only a thin layer of zinc on top, the work passing directly into the lead and emerging upward through the zinc.

A corrosion-proof zinc layer can be produced only in a pure zinc bath, as impurities might later create local elements which start corrosion. [American experience indicates that *extremely* pure zinc is not at all essential to best corrosion protection, and that, everything considered, a grade such as "prime Western" is highly satisfactory. Inasmuch as zinc itself will corrode anyway, the most important factor affecting corrosion protection seems to be the thickness of the coating.—F.P.P.] The structure of an exposed zinc coating consists of 7 layers: (1) Basis iron or steel; (2) iron with zinc diffused therein; (3) FeZn$_3$ [21.5% Fe]—a hard layer; (4) FeZn [10.9% Fe]—also hard; (5) zinc metal; (6) zinc hydroxide; and (7) zinc carbonate. The impurities in the bath should not exceed 2%, *i.e.* 0.03% Fe; 1.20 Pb, 0.05 Cu, 0.05 Al, 0.20 Sn, 0.05 zinc oxide. [These individual maxima may be considered arbitrary by some. Also, no mention is made of the deleterious effect of cadmium on the bending properties of hot-galvanized coatings.—F.P.P.] An immersion of 1-3 min. produces a thickness of 1/10-1/20 mm. (about 1.10-2.2 oz./ft.^{2}) on sheets, structures, etc., and on pipes about half that. The thickness of the injurious hard-zinc layers (Nos. 3 and 4, above) should be as small as possible. The best galvanizing temperature is about 460° C.; immersion time should be as short as possible, depending on shape and weight of the object.

The life of a zinc coating depends on the purity and thickness of the zinc metal layer (No. 5 above), its density, the kind of attacking agents and certain mechanical and physical influences. The corrosion resistance of zinc decreases in the order named for the following agents: The atmosphere, in closed rooms; cold tap and river water; air, rain and wind, according to temperature; damp cement and plaster; seawater—about 2-4 times as corrosive as river water; distilled water—about twice as corrosive as seawater and 7 times as river water; exudations from wood; free alkalies; dilute acids; all chlorine compounds; and lastly, galvanic elements and stray currents.

Examination of hot-galvanized coatings brings H. BABLIK ("The Reaction of Zinc and Iron in Hot-galvanizing", *Iron & Steel*, Vol. 13, Oct. 1939, pp. 2-6) to somewhat different conclusions concerning the nature of the alloy layers. According to him, the phases present as well-defined layers on hot-galvanized iron are as follows: Zinc layer containing 0.03% Fe in solid solution; a layer (a) with 6.0-6.2% Fe; a layer (b) with 6.2-11.5% Fe; and a layer (c) containing 20-27% Fe. Thalemann did not mention the layer containing 6.0-6.2% Fe.

The effect of dipping time is clearly shown in photomicrographs of iron dipped 1, 4, 15 and 30 min., and 4 and 8 hrs. At 1 min. clearly defined alloy layers appear, especially (b) and (a), and with increasing time the former predominates. With short dipping times an unevenness occurs due to the influence of surface pickling, but with longer dips this disappears as a result of dissolution of the iron.

Another series of photomicrographs shows the influence of dipping temperature, and again the (b) layer progressively increases with increasing temperature. Up to 490° C. the (c) and (a) layers are relatively unchanged, but at 495° C. (all dips for 1 hr.) several well-defined, large and dispersed crystals of (a) are formed extending throughout the (b) matrix. It is thought to be the result of a secondary crystallization and it is noteworthy that at this temperature a very heavy attack on the iron occurs, as its solubility in molten zinc is very high. At 500° C. this phenomenon disappears, and with further increases of temperature the (b) layer is completely replaced by a (c) phase.

The structure of the alloy layer is altered markedly by surface contour of the dipped piece. Photomicrographs show the differences noted between concave and convex iron surfaces, and verified by intentional surface scratches. On the concave side no adherent (a) layer exists while one does exist on the convex surface. [This is the layer, incidentally, that Thalemann failed to mention.—F.P.P.] It is shown that at corners there is no (b) layer and a greatly lessened (c) phase. The crystals that form the (a) layer are immediately formed, because of the accelerated attack at this point.

A detailed description of an installation of gas-fired hot-galvanizing equipment of particular interest to small job galvanizers is given by **Fred M. Carlson** of Am. Tinning & Galvanizing Co. ("Gas-fired Galvanizing Equipment", *Metal Ind., N. Y.*, Vol. 37, Dec. 1939, pp. 577-579). His company has operated for 2 yrs. a 7.5-ton capacity welded steel kettle ingeniously positioned in a home-made setting and fired with luminous-flame city gas burners. The shop handles from 4,000 to 15,000 lbs. of work a day, depending on the type of work—mostly pipe straps, bolts and nuts, hinges, pipe fittings, propane tanks, barrels, miscellaneous sheet-metal assemblies and short structural sections.

Two 500,000 B.t.u./hr. (each) gas burners were installed at one end of the setting (one on either side of the 7-ft. kettle) so as to produce a long, luminous flame that could sweep over a central horizontal baffle, down at the other end of the kettle and back under the baffle to a common flue off-take at the firing end. Burners were controllable as to operating heat input, and length and luminosity of the flame. This firing plan assured constant heat input along the length of the kettle, with small temperature gradients. The net effect on kettle life is obvious.

The significance of heat distribution becomes apparent when it is realized that 90% of the work goes through the upper half of the zinc bath, and that the higher temperatures occur at the top of the input end of the kettle, where the greatest heat absorption takes place, then diminishes toward the exit end. The flue-gas heat is utilized in special after-pickling drying tables.

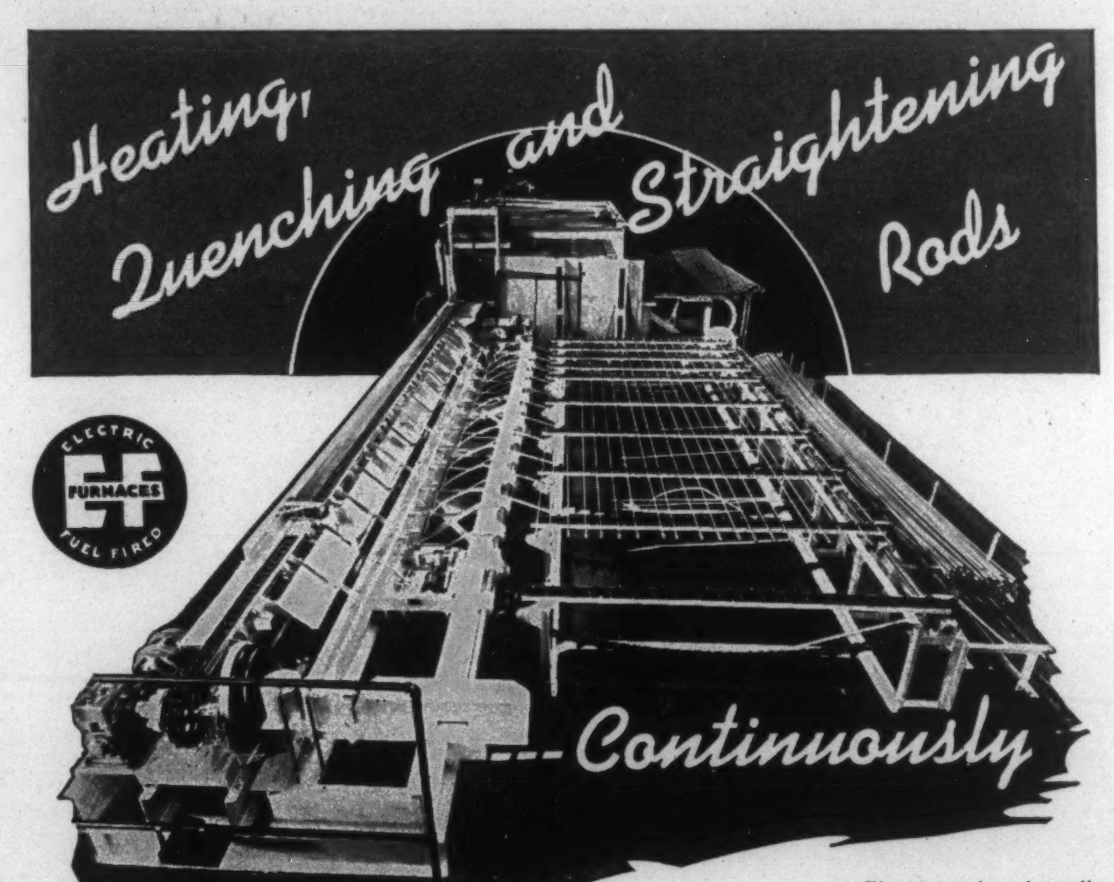
The equipment is claimed to have provided appreciably lower fuel costs, longer kettle life, less dross production, better distribution of heat input and temperature over the outside heated surface of the kettle and better control of metal temperature, greater operating convenience and much more rapid heating-up, and savings in labor for coke-firing and ash-removal. Such equipment is one way for the small job operator to enjoy many of the advantages of the new gas-fired automatic (usually convection- or immersion-tube-heated) galvanizing equipment used by large-scale galvanizers.

Some of the factors involved in one such large-scale job—the hot-galvanizing of steel window-sash—are reviewed by **Wallace G. Imhoff** ("Galvanizing Steel Sash", *Steel*, Vol. 106, Jan. 8, 1940, pp. 47-48). Use of hot-galvanizing for this product is logical, as it answers the home-owner's demand for ample protection, the architect's quest for a satisfactory coating, the contractor's desire for easily-installed windows, and the sash manufacturer's requirement for an economically-produced coating.

The eminent suitability of "prime Western" zinc for hot-galvanizing in general is stressed, the maximum lead and iron contents that are tolerable being given as 1.60% Pb and 0.08% Fe. [Compare with Thalemann's figures, 1.20% Pb and 0.03% Fe, given above.] In fluxing the pickled sash with zinc ammonium chloride or other liquid flux, the sash must be drained well and dried before being immersed in the molten zinc. The liquid flux should dry to a sticky consistency, but should not be so dry as to have lost its water of crystallization, said to be needed as a "lubricator" in the fluxing reaction in the galvanizing bath.

A thick slag flux should be employed on the galvanizing bath to preheat the sash before it passes into the zinc. Recommended galvanizing temperature is 850° F., with 860° F. as a maximum. The sash should be air-cooled rather than water-cooled, after removal and careful draining. A coating thickness equivalent to 2 oz./ft.^{2}, with a minimum of 1.80, is good practice. Preece test should show ability to withstand four 1-min. immersions in copper sulphate solution.

It is recommended that a soft steel base, preferably basic open-hearth steel of 0.13% C and 0.50% Mn, be used. It is suggested that welded steel sash be annealed to re-



The above view shows the straightening and testing machine with the furnace and quench in background.

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move welding stresses that may cause distortion of the product if allowed to relieve themselves in the galvanizing bath—although the author emphasizes that it has yet to be proved that distortion during galvanizing is caused by the relief of welding stresses. X (2a)

Commercial Electropolishing of Stainless Steel

A Composite

Electrolytic *pickling* is of course now a common industrial process and electrolytic *polishing* of non-ferrous metals and alloys has been frequently described in the past. (See, for example, the composite digest in *Metals and Alloys*, Vol. 11, Jan. 1940, p. MA 23). But the electrolytic polishing of stainless steel on a commercial basis is new and still subject to considerable refinement. The present status of this new art and its probable lines of development are given in two recent articles in *Iron Age*, one describing the process used by Allegheny-Ludlum Steel Corp., and the other discussing the subject more generally.

The high cost of mechanically polishing fabricated stainless steel and the practical impossibility of mechanically polishing certain types of products, such as refrigerator trays, were impelling factors in the development of Allegheny-Ludlum's process, described by George Kiefer ("Electrolytic Polishing of Stainless Steel," *Iron Age*, Vol. 144, Dec. 21, 1939, pp. 30-32, 66). While "chemical" polishing methods have been developed that are highly satisfactory for many purposes, the finishes so produced lack the deep luster obtained by mechanical means. However, by using highly concentrated solutions and an electric current, with the work as anode, lusters are obtained that not only equal but surpass the best finish produced mechanically.

Allegheny-Ludlum have found that concentrated phosphoric acid solutions produce a particularly high luster with minimum effort and expense. Articles are suspended in the bath on current-carrying hooks or clamps connected to the positive terminal of the electrical system. Even distribution of the current over the entire area is obtained by suitable design of clamp or hook, which incidentally must be protected by a "stop-off" lacquer or otherwise from the dissolving effect of the electrolysis. Cathodes of "suitable material" are properly spaced around the surface to be polished.

Current required is from 1 to 12 amp./in.^{2} of surface, depending on the cycle, original condition of the surface and the nature of the electrolyte. Three to 4 min. at 2-3 amp./in.^{2} gives a lustrous finish on originally scale-free articles. Relatively low voltage (4-25 volts) is required, the governing factor being the structural condition and shape of the article. Twelve to 25 volts gives a bright finish on forgings and irregularly-shaped articles of large cross-section; 4-6 volts suffices for rolled or thin articles. With the phosphoric acid bath wood or rubber-lined tanks can be used. No heating coils are required because the bath operates satisfactorily at room temperature.

The reduction of cross section in the process is about 0.001 in. or less. Because the finish itself is of submicroscopic thickness, the surface before treatment should be free from pits, scratches, etc. It is more economical to remove scale by a previous conventional acid pickle than by the electrolytic polishing treatment. Electrolytic polishing produces no passivating effect, so the only advantage from the corrosion resistance-standpoint is the extremely smooth, clean surface that is formed.

The type of metal-form (*i.e.* wire or forgings) strongly affects the polishing behavior, as does the composition of the material. Thus, the straight chromium irons do not develop as bright a luster as do the austenitic chromium-nickel alloys. The difference in luster of the two types of materials is less in the case of forgings than rolled products. Present applications of the process include refrigerator shelves, meat trays, small kitchen utensils, rivets, bolts and similar wire products.

Other commercial stainless steel electrolytic polishing processes are described by T. W. Lippert ("Pickle Polished Stainless Steel", *Iron Age*, Vol. 145, Jan. 11, 1940, pp. 22-26). The various processes may be distinguished particularly by the electrolytes used. Allegheny-Ludlum uses the phosphoric acid method (a license from Western Electric Co.). Rustless Iron & Steel Corp. employs a solution of concentrated citric and dilute sulphuric acids. American Rolling Mill Co. has other types of electrolyte in patent application. Sam Tour is working with a concentrated sulphuric and hydrofluoric acid electrolyte.

Rustless and Armco have collaborated in their development—the former specializing on wire products and the latter on sheet and strip. Rustless has two new installations operating in wire-fabricating plants, each capable of polishing 5,000 stainless refrigerator shelves per day. Lead-lined tanks, and comparatively high and closely controlled temperatures [not given] are used. Current density is 0.5 to 1.5 amp./-

in.^{2}. An important feature of these installations is that the electrolytic polishing removes discoloration and oxide scale formed in the spot welding of many wire products.

None of the electrolytes mentioned has a very good throwing power, thus necessitating the use of supplementary cathodes for deeply recessed articles. With some products, cathodes that conform roughly in shape to the work are required, whereas with other (small shallow sheet articles) a cathode of special shape is not needed. No special cathode is required with fabricated wire articles. The brilliant finish obtained on initially smooth-surfaced articles is also obtained on castings and forgings, even though the latter retain after polishing their irregular surfaces. The Rustless and Armco processes, in contradistinction to Allegheny-Ludlum's, are claimed to have powerful passivating effects. The reason for this difference in behavior [if, indeed, any difference actually exists] is not clear.

Electrolytic polishing is no panacea, but will tend to complement mechanical polishing. For articles that can be polished in automatic machines, the electrolytic process can hardly compete. For drawn articles, the new process has as yet not been applied, owing to the fear that electrolytic polishing would not remove scratches, nor give a uniform appearance because of the varying grain structure along the drawn piece. Also, with drawn articles comes the problem of whether the bead shall be closed or left open. (2a)

2b. Non-Ferrous

Forging Magnesium Alloys

"Forging Magnesium Alloys." *Light Metals*, Vol. 2, Dec. 1939, pp. 400-402. Review.

The procedure used in forging magnesium alloys must necessarily be modified from that used with most metals owing to the hexagonal crystal structure of magnesium. Slip occurs only on the basal planes of the magnesium crystals at room temperature, but at temperatures above 220° C. pyramidal planes may function as slip planes. Since, as is well known, metals deform plastically by means of slip or gliding on slip planes, the more slip planes that are effective, the more easily deformable the metal becomes. It is therefore clear why magnesium and its alloys may be readily worked at moderately elevated temperatures, while only a slight amount of working is possible at room temperature.

This is particularly true with the comparatively hard and strong forging alloys containing several per cent of aluminum and other alloying additions. However, at temperatures above 220° C. slip occurs preferentially on the basal glide planes, which are few in number, and slip occurs only on the pyramidal planes after the possibilities of slip on the basal planes are exhausted. Hence even at elevated temperatures, magnesium alloys do not deform as extensively as alloys of aluminum or other face-centered cubic metals. Stress-strain results on magnesium alloys show that in order to obtain maximum deformation, a slow rate of loading must be employed. Therefore in forging magnesium alloys, the hydraulic press is customarily employed instead of the drop hammer or other methods where rapid blows are delivered. Also, with low speeds of deformation, the annealing process has a chance to function during working, thus allowing more deformation than would otherwise be possible.

A feature of the working of magnesium alloys is the development of a marked degree of preferred orientation, a consequence of the limited slip directions. Hence if the working is largely uni-directional, a high degree of preferred orientation may be developed. This is ordinarily undesirable as the finished forging must often be subjected to stresses acting in numerous directions. However, if the applied working stress is essentially uni-directional, advantage may be taken of the preferred orientation since the forging is stronger in one direction than in another. In order to avoid the formation of excessive preferred orientation, the working must be applied in different directions, resulting in a sort of kneading action. Electric furnace heating of billets to be forged is recommended; it is important that the whole section heated attains the desired temperature.

An advantage of the hydraulic press for working magnesium is that utilization of cast steel dies instead of wrought steel dies is possible, owing to the absence of impact stresses on the die. Cast steel dies can not be used with a drop hammer because of the danger of cracking. Certain of the softer magnesium alloys may be successfully forged with the drop hammer. When using the drop hammer it is desirable to use a short drop and gradually increase it as grain refinement progresses and the forging occupies more and more of the die cavity. It is necessary for best results to have the die warm before pressing or there will be an excessive loss of heat of the forging to the die owing to the low density of magnesium.

Alloys containing less than 7% aluminum are best used in the as-forged condition since the response to heat treatment

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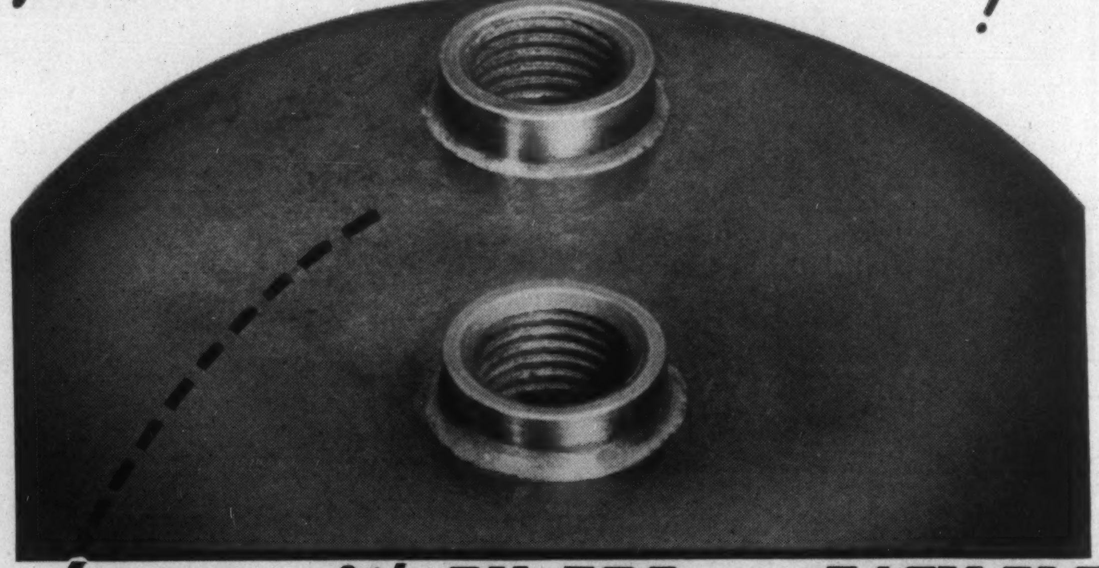

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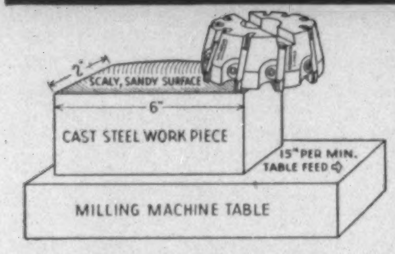

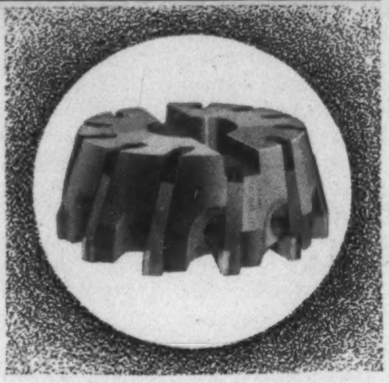

10 blade cutter shown above; 12 blade cutter at right. Photo courtesy McCrosky Tool Corp., Meadville, Pa.

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is relatively low, and by heat treatment the benefits of the slight cold working will be lost. But alloys containing over 8% aluminum are ordinarily heat-treated. Solution-treating may be carried out in either a furnace with a sulphur dioxide or carbon dioxide atmosphere or in a 25% potassium dichromate, 75% sodium dichromate salt bath. AUS (2b)

Electroplating with Sulphamates

ELECTRODEPOSITION OF METALS FROM SOLUTIONS OF SULPHAMIC ACID OR ITS SALTS ("L'elettrodeposizione dei metalli da soluzioni a base di acid solfammico e suoi sali") ROBERTO PIONTELLI & ALESSANDRO GIULOTTO. *Chimica e industria (Italy)*, Vol. 21, Aug. 1939, pp. 478-491. Review plus research.

L. Cambi and R. Piontelli (*Rend. Inst. Lombardo*, Vol. 72, 1938-1939) pointed out the possibility of utilizing solutions of sulphamic acid (HSO_3NH_2) in electrometallurgy. The present authors have determined the current densities and other conditions necessary to obtain satisfactory deposits of various metals. The following metals give satisfactory protective or ornamental coatings: Copper, iron, nickel, cobalt, cadmium and rhodium; the following may be refined by electrolytic methods: Copper, silver, iron, nickel, cobalt and lead.

Optimum conditions for depositing each metal are noted. *Copper* gives satisfactory deposits with up to 550 amps./m.^{2} at temperatures of 12°-30° C.; at 37° C. and 300 amps./m.^{2} a specular deposit is obtained. Copper carbonate ($CuCO_3$) is dissolved in the acid to give a molar solution of copper. Silver solutions are also prepared from silver carbonate (Ag_2CO_3) or by reaction of silver sulphate (Ag_2SO_4) and barium sulphamate [$Ba(SO_3NH_2)_2$]. At temperatures of 20°-60° C. and currents of 40-160 amps./m.^{2}, deposits of silver can be obtained. At 20° C. and 100 amps./m.^{2} compact, fine crystalline deposits almost as good as those from cyanide solutions can be obtained.

Iron is deposited at 17-50° C. and 100-1000 amps./m.^{2}, the best deposits being obtained at 17° C. and 310 amps./m.^{2}. Excellent thin or medium *Nickel* is deposited at 12-40° C. using currents of 70-350 amps./m.^{2}. Excellent thin or medium coats of nickel can be obtained, but extra heavy deposits tend to flake off.

Lead in 1-2 molar solution, with fish glue as protective colloid, can be electrolyzed from the solution with practically complete separation from bismuth, arsenic, antimony or tin. Temperatures of 13°-22° C., at 50-150 amps./m.^{2} were used. The higher temperature gives more compact deposits; by this method it was possible to prepare the pure metal, but adherent deposits were not obtained.

Zinc was electrolyzed at 14°-40° C. and 77-1000 amps./m.^{2}. The deposits are similar to those obtained using sulphate, with no particular advantage in using sulphamate. *Cadmium* behaved like zinc. Rhodium solutions containing 10-20 gm./l. Rh and with excess free acid were electrolyzed at room temperature and 50-100 amps./m.^{2}, using copper or platinum cathodes, and gave very good deposits of rhodium.

All known salts of sulphamic acid except the basic mercury salt are soluble in water. Attempts at depositing tin, manganese, bismuth, chromium, antimony and arsenic were unsuccessful, in fact sulphamates of bismuth, antimony and arsenic are not known, while the tin salt is only very slightly soluble. Manganous salts oxidize very readily. The possible deposition or refining of platinum or gold by means of sulphamic salts is still under investigation. AWC (2b)

Welding Magnesium Sheet

"WELDING MAGNESIUM ALLOY SHEET." "AGRICOLA." *Sheet Metal Ind.* Vol. 13, Nov. 1939, pp. 1375-1379. General review.

The welding properties of Mg alloys are similar to those of Al in many respects: Low melting points, high conductivity, and considerable expansion on heating. There are, however, two important points of difference: The greater notch sensitivity of Mg alloys, and the greater liability of Mg alloys to crack during working and welding (hot working is therefore preferred). Burning is not so dangerous in welding as in fine machining, because of the high thermal conductivity.

Oxyacetylene welding is generally used, owing to its superior flexibility. As a result of the corrosive nature of the flux used, it is essential to prevent inclusions in the weld; therefore all lapped joints must be avoided. All sheets thicker than 12-gage (0.080 in.) should be bevelled to about 45°. The naturally-formed protective oxide film should always be removed from the edges to be welded. Design of jigs is important, since the metal must not be stressed while it is hot if cracking is to be avoided. The normal expansion allowance is 0.25 in. per linear ft., for 12-gage metal. Owing to the danger of corrosion, the filler rod must be of the same composition as the parent metal. Fluxes consist mainly of magnesium chloride with varying amounts of alkali and sometimes other additions. The flux should be applied sparingly and carefully removed immediately after welding. Preheating is seldom required. The flame should be very slightly reducing. Over-heating results in gas absorption and porosity; the surface of the weld will then be gray-brown or white. After the flux has been removed with hot soapy water, the welded article is immersed for at least 1 hr. in a 70° C. solution of 5% potassium bichromate to neutralize any remaining flux. The article must then be treated by the selected protective medium (usually chromate treatment) at once.

Resistance welding has the advantage of requiring no flux; in Germany metal up to ⅛ in. thick has been resistance welded giving liquid-tight seam welds, but considerable distortion may result. The welds have the properties of the as-cast metal, with lower ductility than worked and annealed metal. Inspection includes visual examination (more revealing than with most metals), radiographs, and corrosion testing; if the flux has not been entirely removed, "rust" spots will show up after short exposure in water or in a humid atmosphere. JZB (2b)

Mechanism of Age-hardening

"THE THEORY OF AGE-HARDENING." KOTARO HONDA. *Nippon Kinzoku Gakkai-Si,* Vol. 3, Oct. 1939, pp. 359-365. In Japanese. Review-discussion.

Two theories, the distortion and precipitation types, have been proposed for the age-hardening of quenched alloys, but neither of them alone is satisfactory for the explanation of a large number of observed facts. The author's view of the age-hardening phenomenon is as follows:

Precipitation can take place only when the dissolved atoms have locally assembled themselves within the lattice of solvent atoms, thereby distorting the lattice and causing hardening of the alloys. On the other hand, the precipitation itself causes a softening of the alloy ground-mass, but the presence of precipitated particles in the solvent alloy causes a hardening of it by the slip interference of the precipitate. The net result of these three effects will, at room temperature, generally be a hardening, but in some cases it may be a softening.

Thus, by aging a quenched alloy, the solubility of which for a certain element rapidly increases with the rise of temperature, hardening is at first observed, followed by a softening. Let H_g be the hardness of the ground-mass containing a certain element in solid solution under equilibrium conditions, and H_p the hardness increase due to precipitated substance; then the resultant hardness H is given by

$$H = H_g + H_p$$

If an alloy be quenched from a high temperature, its hardness is increased through the formation of a super-saturated solid solution by ΔH_s, but its hardness also decreases by a certain amount ΔH_p through the diminution of the precipitated substances; hence, the *quenched* alloy has a hardness:

$$\begin{aligned} H' &= H_g + \Delta H_g + H_p - \Delta H_p \\ &= H + \Delta H_s - \Delta H_p \end{aligned}$$

or

$$H' - H = \Delta H_s - \Delta H_p$$

In the case of aluminum-copper, aluminum-magnesium silicide and duraluminum alloys, ΔH_s is greater than ΔH_p, and therefore H′, the as-quenched hardness, is greater than H, the simple solid solution hardness. On the other hand, in the case of silver-copper and magnesium-aluminum alloys, the quantity of precipitated substance is large and so ΔH_s is less than ΔH_p and therefore H′ is less than H. Hence, in these alloys, the quenching causes a softening.

During aging at room temperature the alloy becomes hardened by the distortion, ΔH_{dist}, of the lattice caused by the local concentration of the dissolved atoms before the precipitation; at the same time, the gradual decomposition of the solid solution decreases the hardness by ΔH_{dec}, and increases it by the formation of precipitated substance, that is, by ΔH_p. Hence, the change of hardness by aging is given by

$$\Delta H = \Delta H_{dist} - \Delta H_{dec} + \Delta H_p$$

Further, on aging at high temperatures, coagulation of the precipitated particles takes place, resulting in a softening amounting to ΔH_{coa}, so that

$$\Delta H = \Delta H_{dist} + \Delta H_p - (\Delta H_{dec} + \Delta H_{coa})$$

The above four terms are all zero immediately after quenching, but they gradually increase with lapse of time; ΔH_{dist} increases linearly at first and then approaches a certain value asymptotically. The increase in hardness represented by ΔH_p starts a little later, and increases similarly to ΔH_{dist}, but to a lesser degree. The hardening effects represented by ΔH_{dec} and ΔH_{coa} are also later than that of ΔH_{dist}. Hence, the resultant hardness for a definite time can be obtained from curves of these four terms. The resultant curve takes various forms according to changes in the form of the compound curves

Again, if ΔH_{dist} be large as compared to ΔH_p, then the age-hardening corresponds to the distortion type, but if the reverse is true, it corresponds to, or appears to be of, the precipitation type. There is no case in which the age-hardening is due solely to either distortion or to precipitation. NS (2b)

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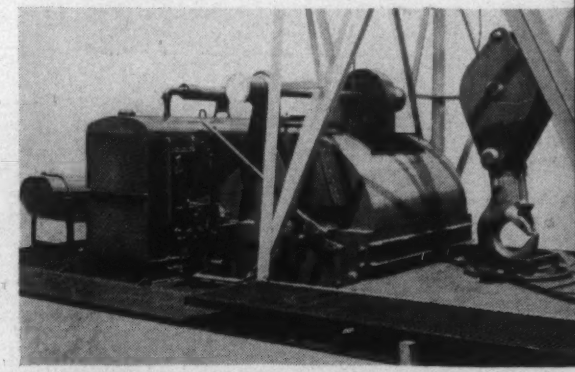

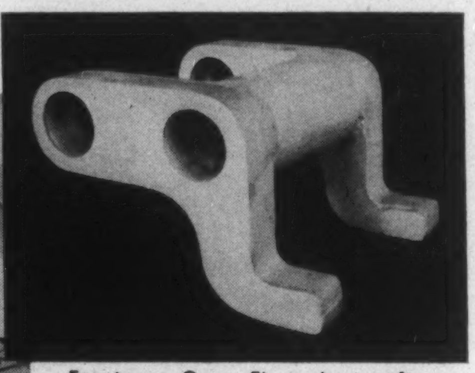

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3 Properties and Applications

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Metals in Railway Cars

"Railway Car Engineering." D. S. Ellis (Chesapeake & Ohio Railway Co.) *Mech. Eng.*, Vol. 62, Jan. 1940, pp. 18-22. Review.

Because of the competition for passenger travel from airplanes, buses and private automobiles, the railroads are seeking strenuously to improve the factors of safety, comfort, travel cost, speed and appearance that individually or together determine the public's choice of conveyance. As a result, important developments have produced a new era in car design and methods of construction. Foremost among these, from the metallurgical engineer's viewpoint, have been:

(1) New and improved construction materials, such as aluminum alloys; low-alloy, high tensile steels; and stainless steels.

(2) Modernized fabricating methods in which welding by the arc, shot and spot systems are used in place of the usual riveted construction.

(3) Reduction of weight where possible by the use of alloys of adequate strength, tending to reduce the destructive forces of kinetic energy in case of accident.

The properties of those alloys thus far utilized in car construction are given in a table, part of which is reproduced here.

Material	Form or Application	Heat Treatment	Mechanical Properties		
			Tensile Strength lbs./in.^{2}	Yield Point lbs./in.^{2}	Elongation in 2 in., %
18/8 stainless, high tensile	Sheets and strips	Cold-rolled, reduced	150,000	110,000	9
18/8 stainless	Angles, shapes and bars	As-rolled	90,000	45,000	55-60
Low-alloy Steel	Plates, shapes and bars	As-rolled	65-90,000	50-65,000	38-22
Low-alloy Steel	Sheets and strips up to 3/16 in. thick	Normalized or annealed	65,000	50,000	22
Aluminum Alloy, 17 ST	Plates, angles, channels	Heat-treated	60,000	37,000	22
Aluminum Alloy, A 17 ST	Carlines, posts, purlines, window headers, belt rail, floor beams, side sill, extruded sections and sheets	Heat-treated	43,000	24,000	27
Aluminum Alloy, 53 ST 5	Window sash, exterior trim and side sheet, and extrusions	Heat-treated	39,000	33,000	20
Aluminum Alloy, 4S	Roof and girder sheets	Half-hard, not heat-treated	34,000	27,000	12
Aluminum Alloy, 61 ST	Plates, sheets and extruded sections	Heat-treated	45,000	39,000	12

The improvements in materials, design and construction methods applicable to passenger equipment have also been applied to a limited extent to freight equipment—chiefly to reduce operating and maintenance costs, and increase pay loads. Several hundred so-called lightweight cars, of various types, incorporating low-alloy high-tensile steels and fabricated by welding are now in use, and represent a distinct improvement over earlier types, especially as to operating costs and increased pay-load. These savings will be augmented by any relative increase in corrosion resistance over that of copper-bearing steel. Since most of the comparative tests made to date have been with atmospheric corrosion, the results of present investigations on relative performance in coal-carrying equipment are eagerly awaited.

Welding technique and equipment have been developed to such an extent that reliable results are the rule. An Assoc. of Am. Railroads report covering impact tests up to 13 miles/hr. on a boxcar fabricated almost entirely by arc and spot welding showed no defects; a close inspection of 14,000 spot welds failed to disclose any indications of weakness or failure.

A comprehensive, extremely detailed table offers a comparison of general dimensions, weights and structural details of 50-ton lightweight steel-sheathed boxcars built by various companies, and the Assoc. of Am. Railroads 50-ton standard steel-sheathed car. The complete-car-weights of the lightweight boxcars are about 37,400 lbs.; of the A.A.R. standard car, 45,200. The load limits are, for the newer cars, about 131,600 lbs.; for the old type, 123,800.

Some of the cast steel construction of the standard car has been replaced with welded high-strength steel, built-up, but cast steel truck side frames are used in all cars, new or old. Two of the lightweight car manufacturers are using conventional cast steel truck bolsters, while the third has gone to "high-tensile, alloy steel". For couples and coupler yokes, some of the lightweight cars employ high-tensile, low-alloy steel castings as compared with ordinary steel castings on the standard car. One lightweight car manufacturer is experimenting with lightweight chilled-iron wheels, each weighing 695 lbs., as compared with the standard wheel of 750 lbs.—a total saving of 440 lbs. per car.

The trend in new passenger car equipment is believed to be toward greater use of alloy steels with their collateral methods of fabrication, and the use of less expensive interiors than in recently-built cars. New freight cars, acquired in considerable numbers, are likely to represent a compromise between the extreme lightweight construction ultimately possible and the heavy construction used for such rolling stock in recent years. FPP (3)

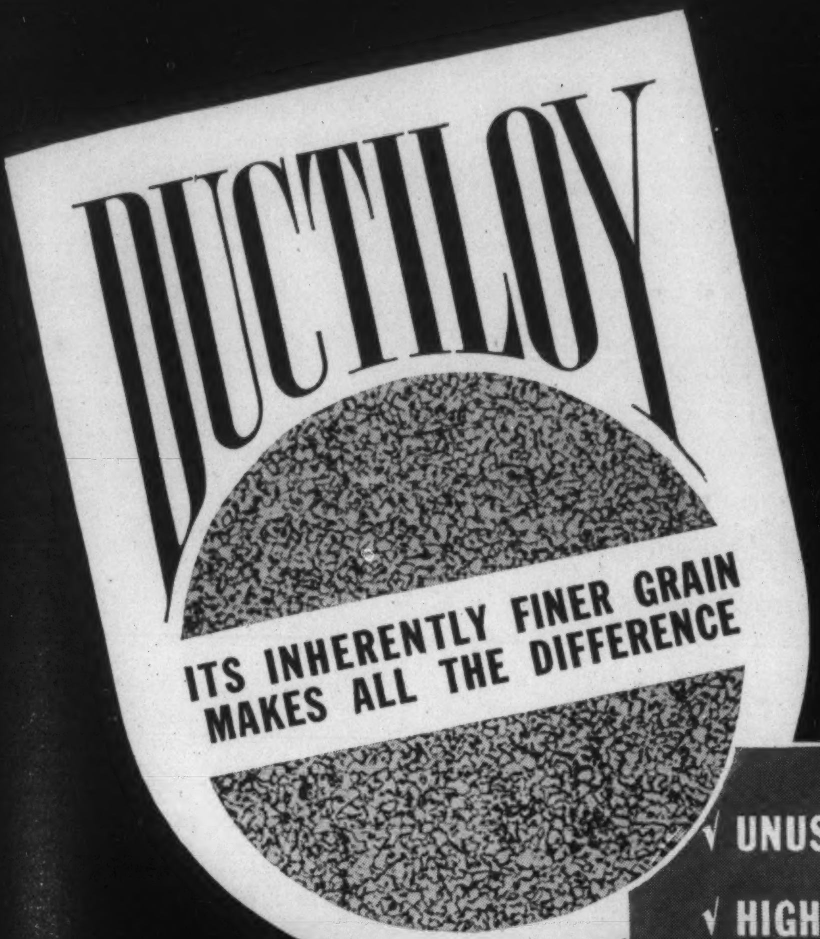
"Pre-finished" Tinplate Articles

"A Novel Use for Tinplate." B. W. G. *Tin and its Uses*, No. 3, Oct. 1939, pp. 4-5. Descriptive.

Tinplate is ordinarily associated with food packing and a wide range of inexpensive metal utensils and fittings, but its use as a material for decorative articles that do not come into contact with food products is less well known, for in many cases it receives a finishing surface of copper, brass, nickel or chromium.

A recent development in America is to avoid the final surface treatment of the fabricated article by the mass production of "pre-finished" tinplate sheets. These need only to be stamped or formed into the finished article, without any final plating, buffing or polishing operations. "Pre-finished" tinplates are therefore particularly useful for the manufacture of articles of intricate shape, where plating and polishing after fabrication would be expensive. Tinplate has many advantages as the base metal on which a thin ornamental surface can be plated. The protective nature of the tin enables it to be stored almost indefinitely without danger of rusting and it is made in such vast quantities that the tinned sheet is practically as cheap as polished untinned steel, while the soft tin surface takes the necessary high finish with only the least expensive polishing operation.

In the mass production of "pre-finished" sheets the metal surface-coating is applied under controlled conditions to give a bright finish. Copper is deposited directly on to clean tinplate, but for nickel and brass surfaces a copper undercoat is necessary, and for the chromium finish deposits of first copper and then nickel are applied before plating with chromium. These compound coatings of course increase the durability of the product. Three American plants now use from 2,500 to 5,000 tons of tinplate annually in the manufacture of their "pre-finished" metal sheets. Ordinary prime coke tinplates, such as are used for



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making tin cans, are generally used in this industry, though for some purposes special grades are employed. The tin coating need not be heavy, but it must be free from blemishes. The standard size for "pre-finished" sheet is the usual 28 in. x 20 in., but any size obtainable from the tinplate mills can be used. Similarly, many thicknesses of sheet are available, varying from 0.0063 in. to 0.0225 in.

Tinplate produced by the modern cold rolling process when "pre-finished" and subjected to deep forming operations is believed by many to have a tendency to flake, although the coating is perfectly adherent on hot-rolled tinplate. The hot rolled tinplate is therefore preferred under some conditions of stamping, though for most purposes the more ductile cold reduced plate is used. At present no tinplate is "pre-finished" in continuous coils. When the sheets are to be subjected to drastic stamping or drawing operations they are sometimes coated with paper by means of a gum adhesive, to protect the finish, the paper being afterwards peeled away and the gum wiped off.

"Pre-finished" sheets can be made in almost any finish desired by the consumer—brilliant and reflective, striped or check, corrugated, scored, or lacquered. Before applying colored lacquer the tinplate is given a bright coating of copper. Some of the already numerous and diversified applications of "pre-finished" sheets are illustrated. For buttons and buckles, hair brushes, and hand mirrors the lacquer- and metal-finished tinplate is often backed with another material, such as wood. (3)

Metals and Plastics

A Composite

The competition among various materials and material-forms seeking incorporation in today's products is becoming ever keener. It isn't always easy for the engineer or designer to decide whether to make a given article of steel or aluminum; of zinc-base alloy or brass; of stainless or chromium-plate, and so on. It is often even harder to decide what metal-form or fabrication process shall be used—die castings or stampings; sand castings or forgings; castings or welded fabrication; machined parts or die-formed. And beyond all this, the designer must often choose between metal and glass, or metal and wood, or—most frequently these days—between metal and plastics.

Although in a surprisingly large number of cases the applications of plastics can be regarded as new articles made possible by plastics, it must be conceded that these modern products of chemical ingenuity are being successfully substituted for metals in a variety of important applications. Such competition should certainly be a stimulant to the development of new or better alloys, improvement in metalworking processes, or more functional metallurgical design.

The extent to which plastics have become part of our industrial and everyday life, often at the expense of metals, is broadly indicated in a review of "product development" appearing in *Modern Plastics* (Vol. 17, Oct. 1939, pp. 5-20). Industry naturally consumes a great quantity of plastic products in addition to producing them for consumer use. Laminated plastics, because of their ability to resist wear, abrasion and corrosion are used as gears; they are quiet and may be lubricated with water. Industrial machinery also employs such materials where great strength and a perfectly smooth surface are required, as in bearings. Small machines and other tools employ plastics as housings because the material serves as insulation and provides a smooth, easy and lasting grip of excellent appearance.

In motor cars, plastics are used as laminated gears, as shafts, knobs, trim, nameplates, instrument panels, headlamp parts, steering wheels, etc. In business machines, these materials are used not only for keys but for housings as well. Even office chair legs enjoy the protective benefits of molded scuff plates, and casters are frequently molded from phenolic materials. In the home, plastics have replaced metals in some radio set parts, ashtrays, brush-handles, lamp shades and reflectors, door knobs, cabinet hardware, etc. In recreational and sporting equipment the inroads of plastics have been notable, chiefly for camera cases, rifle parts, fishing reels, spoons, bobs and synthetic bait—because of their attractiveness, lightness, strength and corrosion resistance.

The metal-forms with which plastics seem to be most competitive are die castings and stampings. An excellent comparison of the design advantages and relative costs of die castings and plastics has been given by Herbert Chase ("Die Castings or Plastics", *Product Engineering*, Vol. 10, Aug. 1939, pp. 320-325). Some generalized comparisons can safely be made, and these are given in a highly useful table; specific comparisons based on actual designs are also included, and are confined to zinc-base die castings and molded phenolic plastics, which in their respective categories, usually rank lowest in cost per piece and high in most significant properties.

Generally speaking, the plastics have an advantage in lightness, in smoothness of surface obtainable, in finished appearance (and in usual ability to dispense with externally applied finishing). Metals have higher thermal conductivity, which may be a distinct advantage or an actual disadvantage, according to the application. Metals are electrical conductors; plastics are dielectrics. The cost/lb. range seems to be slightly favorable to the die casting alloys, although the raw material price ranges in each group are extremely broad. The cost per piece, without applied finish, is more often than not favorable to die castings. Machining costs are likely to be lower for die castings, but fin removal often costs more.

The real advantages of die castings as compared to molded plastics are greater strength (although plastics are sometimes stronger on an equal-weight basis); satisfactory resistance to the effects of temperatures up to 300° F., in which range most plastics distort or discolor; malleability; amenability to more complex design; greater permissible variations in section thickness in a single part; higher dimensional accuracy (0.001-0.003 in. as compared with 0.005 in./in. for plastics); lower cost of dies; usually higher production rates; and customarily negligible waste in scrap, as compared with considerable waste for plastics. Several case studies, in the form of appearance, operating and cost elements involved in actually making certain described products of die castings and also of plastics are given.

An interesting compromise between metal (stampings) and plastics for the unit parts of an automatic sales register is described by Chase in another article ("Plastics for Stampings", *Iron Age*, Vol. 144, Aug. 17, 1939, p. 49). In this, the former design had been a drawn aluminum shell welded to the chassis for further weight stiffening. The disadvantages in this design included frequent distortion of the case in service and displacement of operating mechanism, and considerable difficulty in working inside the sheet metal case with the chassis welded to it when assembling chassis parts. Making the case of plastic considerably improved the appearance, eliminated distortion in service as the case was stiffer (thicker section, ribbed, but no heavier in weight than the aluminum shell), decreased tooling cost and total-part cost, eliminated denting of the housing, and provided sharp detail and satisfactory contour. The case was fastened to the chassis base through ledges on the former with integral bosses with threaded insert. Rathbun spring clip hinges could be used as they are easily and quickly snapped into place in molded recesses.

A quite different set of conditions apply to the interior parts, a large proportion of which are stampings involving simple blanking, bending and piercing, with a limited number of assembly-welds. Appearance is not a factor, and the use of light gages makes the stamped parts inexpensive and decidedly satisfactory.

Still another instance in which metal parts have been displaced by plastics is described by G. O. Small ("New Material for Speed Cams", *Modern Plastics*, Vol. 17, Dec. 1939, pp. 30-31, 76-80). The demand for higher operating speeds in leather stitching machines used by the shoe manufacturers and others, brought about redesign and substitution of molded-laminated plastic cams for the cast iron cams formerly used. Exhaustive tests and actual service performance show the plastic parts in the new stitcher to be responsible for an impressive list of improvements over the metal members they replace. The plastic cams weigh 1/5 as much as their cast iron predecessors, cost 30% less to install, have less noise and vibration, require less lubrication, and have permitted an increase of 200% in the speed of the machines, without distress even at an overload of 50%.

Proposals to replace sheet metal automobile fenders, panels or complete bodies with plastic construction are examined informally by S. G. Saunders ("A View of Organic Plastics by One in the Automotive Industry"—abstracted in *Iron Age*, Vol. 144, Aug. 24, 1939, pp. 59-62). He says, broadly, that the automotive industry is a bit skeptical that accomplishments to date make plastics fit to replace steel in any of the fundamental or structural parts of the automobile. However, when plastics pass the decorative stage and are both decorative and structural, they might be used for inside door panels, grilles, head lamps, hub caps, gas tanks, pumps, pulleys, oil pans, transmission cases, body panels, fenders, etc.

To save weight and to reduce production costs, the automotive industry would quickly discard steel for another material if the latter involved no quality or performance sacrifice. If plastics are to be seriously considered, however, they must possess tensile strengths of 40,000 lbs./in.^{2} [present best figure is about 10,000] to compete with body steel, with compressive strength equal to this and shear strength no lower than ¾ of this figure. Plastics will have to have their modulus of elasticity increased to 12-15 million [present best values are about 4.5 million, with most values less than 1 million], to keep deflections within good production and engineering limits, as compared with cast iron and steel, and should not undergo dimensional change at low stress. They must also be made to withstand the effects of high and of low temperatures much better than at present. From the production standpoint, the automotive industry could not tolerate the currently long heating time used in molding and forming plastics be-

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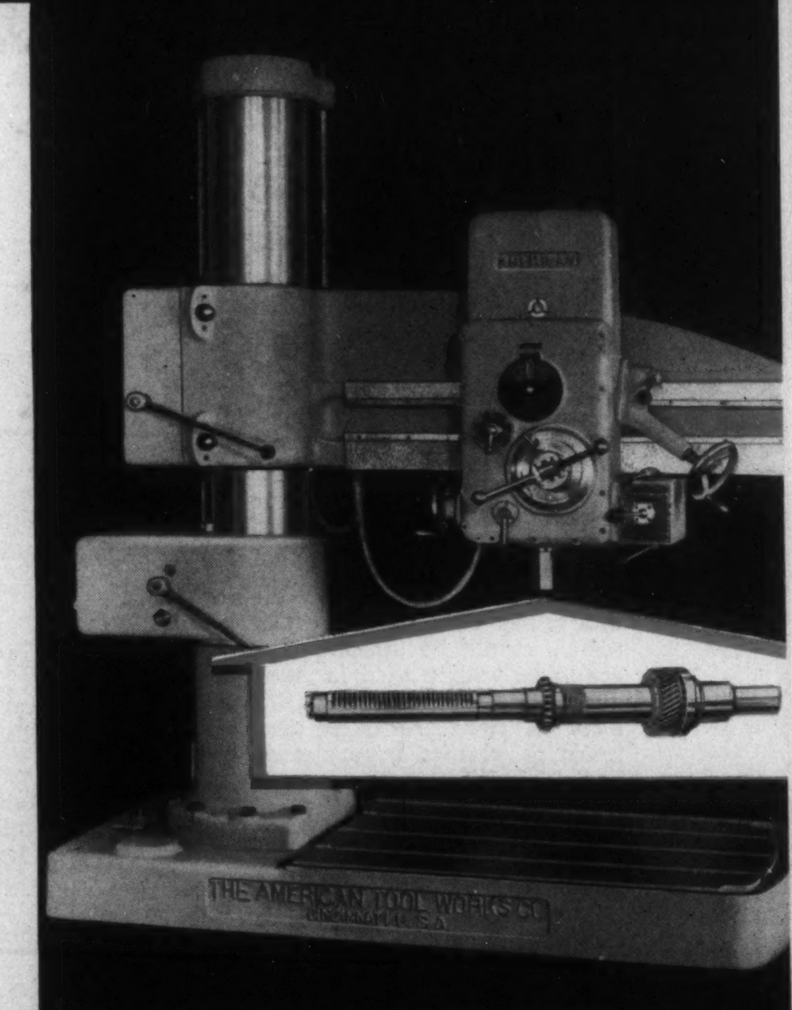

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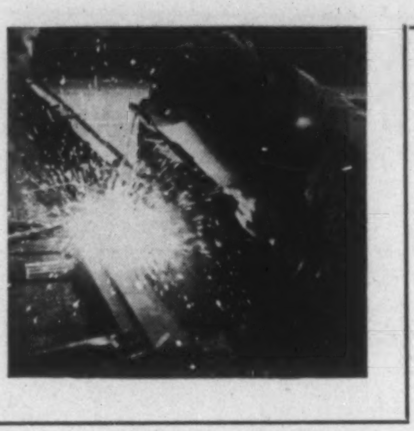

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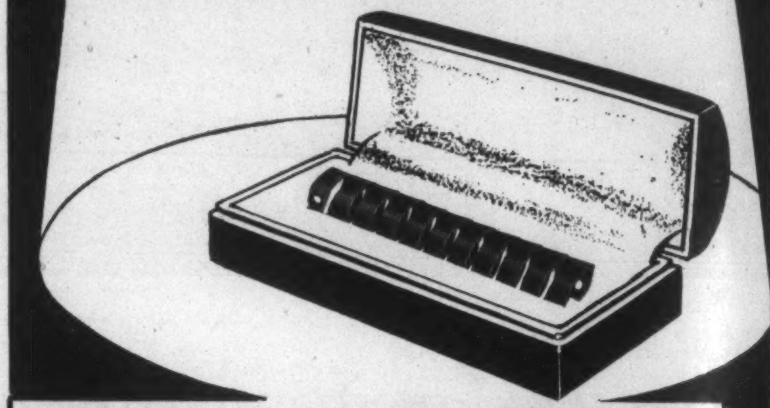

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cause of the long "idle time" for dies and presses thus involved. Also, plastic parts will have to be amenable to repair, as by gluing, patching, building-up, etc., or by some heating process similar to the welding of metals. They must, finally, be fireproof and shatterproof.

[These suggestions were all made to indicate the direction in which plastics research should be directed if such materials are to be widely used in automobiles. Such aims are not at all impossible of achievement in time. In other products the inroads of plastics have already been great, and logically so. To protect its markets, the metal-producing and fabricating industries must meet this newest challenge not only by developing new alloys and improving the old, but by investigating and bettering processing and fabricating methods; stimulating design studies to determine where die castings, stampings or formed and drawn parts may not actually have been underrated; and providing means and products by which metals and non-metals may function in complementary, supplementary or composite fashion.—F.P.P.]

X (3)

3a. Ferrous

Engineering Irons

"CAST IRON IN ENGINEERING CONSTRUCTION—13." J. L. FRANCIS. *Iron & Steel,* Vol. 12, Sept. 1939, pp. 725-730. Practical review.

Chromium is used in cast iron (alloyed with nickel) to maintain hardness during tempering. Chromium is helpful in this respect because of its property of forming stable carbides with the high carbon present. The best results are obtained with low carbon and silicon contents. A table is included giving the properties that can be obtained by suitable heat treatment. The following properties were found after the heat treatment indicated in a cast iron containing 2.5% Ni and 1.0% Cr.

Treatment	Brinell Hardness	Tensile Strength lbs./in.^{2}
As-cast	250	48,000
Oil-quench, 880° C.	470	30,000
Temper, 385° C.	380	50,000

Cast iron containing 4% Ni and 1.5% Cr can be hardened by air-quenching from 850° C. without great loss of toughness, and without distortion. Bars of cast iron containing 1.68% Si, 0.65% Mn, 1.8% Ni and 0.46% Cr can be quenched in oil from 850° C. and tempered at 550° C. with an increase in tensile strength from 30,000 to 40,000 lbs./in.^{2}, with no increase in hardness over that as cast.

The most important and useful properties of malleable iron castings are their good strength, ductility, shock-resistance and machinability. Copper is the most widely used alloying element in malleable cast iron. To counteract the graphitizing action of copper, the silicon content should be lowered 0.1-0.15% for each 1.0% copper. The time necessary for carbide dissociation during annealing is reduced about 25% for 1% copper, and about 50% for 1.5-1.7% copper. Greater assurance of complete malleableization is afforded when operating under ordinary doubtful conditions.

Copper refines the grain and promotes smaller and more numerous temper carbon nodules, giving increased tensile strength, yield point and impact values with, however, a decrease in elongation as much as 20% for 1.25% Cu. Danger from galvanizing embrittlement is lessened by 3% copper, titanium being added to counteract the resulting loss in elongation. A small amount of precipitation hardening is possible when the amount of copper present exceeds the solid solubility limit. Other alloying elements used in conjunction with copper in malleable iron are manganese, nickel, chromium, titanium, molybdenum and vanadium.

By the addition to malleable iron of 0.5% molybdenum the carbon-plus-silicon can be increased from the usual 3.75% to 4.4%, so that with 2.6% total carbon the silicon can be 1.8% without the iron turning gray. This shortens the annealing period and results in increased tensile strength and elongation by solution of molybdenum in ferrite. The castings are also less inclined to crack in the mold and are less susceptible to gas shrinkage. Molybdenum imparts greater transverse strength with better deflection values and increased resistance to corrosion by weak acid, tap water and alkaline solutions.

Titanium facilitates the annealing of malleable since it is an even more active graphitizer than silicon, and therefore must be carefully controlled. It refines the structure in black-heart malleable and gives improved tensile strength and elongation.

Tensile strength, reduction of area and elongation are improved by aluminum additions of 0.01-0.05%, but with more than 0.08% the fluidity decreases. Additions of 0.9-1.3% cause a 50% reduction in tensile strength and an even greater drop in elongation. Aluminum is a graphitizer and also tends to change temper carbon from nodular to flaky form. As an alloy addition aluminum is not beneficial, but it is useful as a graphitizer in amounts approximating 0.01%.

Nickel is a graphitizer—more active than copper but less active than silicon.

Nickel-bearing malleable is commercially made, and the grain refining influence gives added tensile strength and ductility. Care must be employed or primary graphitization of white castings will result. About 1.0% nickel is recommended as the content giving the best mechanical properties.

In spite of its carbide-stabilizing effect on material necessarily graphitic, chromium is often used in malleable cast iron where corrosion and wear resistance are essential. Strength and hardness are increased at the expense of ductility. Chromium is normally used in conjunction with nickel or copper, either of which tend to restore the ductility.

A general discussion of centrifugal casting is included, with special attention to spun sorbitic cast iron. This is an exceptionally good wearing iron and is made by subjecting the casting to a regulated wet air blast during casting. A typical analysis is 2.03% graphite, 0.97% combined C, 1.31% Si, 0.42% Mn, 0.11% S, 0.34% P and tensile strength ranges from 52,000 to 58,000 lbs./in.^{2}.

For nitriding, a specially suitable alloy is available, known as Nitricastiron—2.6% total carbon, 1.23% combined C, 2.58% Si, 0.61% Mn, 0.07% S, 1.69% Cr and 1.43% Al. The castings are treated in an atmosphere of anhydrous ammonia gas at 500° C. in a gas-tight container, as in normal nitriding practice. Nitriding is favored by prior hardening and tempering of the castings, such as quenching in oil from 850° C. followed by a stress relief anneal at 600° C. Treatment extends from 60 to 90 hrs. and castings are cooled in the ammonia atmosphere, the resulting penetration being 0.01-.018 in. Aluminum paint protects selected portions covered by it from the nitriding action. The above analysis furnishes an air-hardening casting, so annealing and slow cooling are essential if machining is to follow. See also *Metals and Alloys*, Vol. 10, Oct. 1939, p. MA 618L/7. HFT (3a)

High-Temperature Piping

"THE SELECTION AND APPLICATION OF HIGH TEMPERATURE PIPING MATERIAL." E. H. KRIEG & G. SONDERMAN (Am. Gas & Elec. Service Corp.) *Welding J., N. Y.*, Vol. 18, Nov. 1939, pp. 697-701. Informative survey.

In 1920 power plants were designed for steam conditions of 250 lbs. and 600° F. requiring 1.5 lb. of coal per kw.-hr. These operating limitations were dictated by the lack of suitable metals for boilers, turbines and piping. In 10 yrs. metallurgical developments permitted the attainment of pressures of 1250 lbs. pressure and temperatures of 750° F., with fuel consumption of 1 lb. of coal per kw.-hr. By 1937 further improvement in metals had pushed the limits to 1250 lbs. and 950° F., and one station is now building for 2500 lbs. boiler pressure with 950° F. at the turbine.

The selection of tubing material has been narrowed down to carbon-molybdenum steel with 0.5 molybdenum because of its high creep strength and stability with respect to corrosion attack by steam. Recently other steels have been examined as to their suitability for the higher steam pressures desired and among those considered were carbon-molybdenum with 1% molybdenum, 5-6% chromium-molybdenum, and chromium-silicon-molybdenum. There is a question as to whether the alloys of the other types than the standard carbon-molybdenum with 0.5% molybdenum show a sufficient improvement in reduced creep rate to justify their higher cost. There has been in the past considerable variation in the creep rate of the 0.5% molybdenum steel but the research data are now so voluminous as to justify an opinion that control of the creep variables is at hand. Thus, some fear has been expressed that the carbon-molybdenum may be an unwise choice because of the submicroscopic changes that may take place in overstressed material, with consequent brittle fractures. Spheroidization in the carbon molybdenum steel at 950° F. to such a degree as to seriously reduce the creep rate would occur only after many thousands of hours of service. The variation in creep rates of carbon-molybdenum steels are shown to be related to their grain sizes. A non-uniform grain size, duplexed structures, and the presence of excess aluminum, which raises the grain coarsening temperature, are all undesirable for maximum creep strength.

It is therefore suggested by the authors that carbon-molybdenum steel be specified in accordance with A.S.T.M. Spec. A206 and supplemented by the following requirements: (1) The steel should have a ferrite grain size of 4-5; (2) it should be free from excessive ferritic banding (micros are shown of permissible and excessive amounts); (3) there should be no evidence of stress such as indicated by distorted ferritic grains (which are illustrated); (4) there should be no evidence of spheroidization; (5) a uniform preponderance of one grain size is much preferred to steels with a tendency to duplex grain structure; (6) steel should be of such composition and so manufactured that the foregoing requirements can be met by heat treatment at a temperature not to exceed 1700° F. with

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These steels have such excellent weldability that full-strength welds in the material are assured. Also, the available welders have developed their technique for the steel to a higher degree than for any other of the alloy steels. In welding the pipe it was found necessary to use backing rings to prevent entrance of spatter and icicles inside the pipe, which could damage the turbine, etc. The use of the backing ring introduced a number of problems, which have been eliminated through the adoption of a new design of weld that precludes the use of backing rings. The welding specifications are described and are shown to be quite rigid and so set up as to give the maximum control of the quality of the welds laid down. WB (3a)

Copper in High-Tensile Steels

The Effect of Low Copper Content on the Tensile Properties of High Strength Structural Steels ("Die Wirkung geringer Kupfergehalte auf die Festigkeitseigenschaften von Hochbaustählen") E. Houdremont, H. Bennek & H. Neumeister. *Arch Eisenhüttenw.*, Vol. 13, Sept. 1939, pp. 137-148. Original research.

A survey of the literature indicated that Cu contents up to 0.5% had a negligible effect on the tensile properties of low-C steel cooled slowly so that no hardening occurred. But Cu does have a decided hardening effect with faster cooling rates. In higher strength steels with enough alloy content for some air hardening to occur, a few tenths % Cu may raise the yield and tensile strength from 1,000 to 4,000 lbs./in.^{2} In studies of a series of steels with 0.17% C, 0.5% Si and 1.5% Mn, some with 0.15% Cu and others with 0.45% Cu, these Cu additions tended to raise the yield strength from 1,000 to 5,700 lbs./in.^{2} and the tensile strength up to 3,000 lbs./in.^{2} In steels with 0.18% C, 1.1% Mn and 0.3% Cr the effect of Cu was less distinct.

The tests indicated that an addition of 0.5% Cu to St 52 not only raises the corrosion resistance but also improves the mechanical properties. It was concluded that Cu was well worth its cost in St 52 as an aid in meeting the specifications. For welding, Cu has the advantage that it is not prone to cause air-hardening or brittleness about the weld. SE (3a)

3b. Non-Ferrous

The Platinum Metals

"The Platinum Metals in 1939." Chas. Engelhard (Baker & Co.) *Nickel Information Service,* Jan. 1940. Review.

World production of platinum metals in 1939 will approximate 500,000 oz., and world consumption appears to be proceeding at a rate that will about equal production. Exports from the United States, which were largely made to France, Germany and Japan, will probably not exceed normal; since the outbreak of the war such export deliveries have *diminished*, particularly to Germany. With the beginning of the war, demand pressure forced the price of platinum from $35.00 to $42.00/oz., iridium from $65.00 to $175.00/oz., and ruthenium from $35.00 to $39.00/oz., but palladium and rhodium prices held steady throughout.

Because the gold supplies of many countries are limited, there is an increasing demand for platinum metals, and particularly palladium, as substitutes for gold in dental alloys and otherwise. Palladium has been used as a substitute for gold in fountain pen points, watchcases, rings, spectacle frames, etc. with marked success, for the reason that 1 oz. of palladium will replace 2 oz. of gold when considering both price and specific gravity. Moreover, it was found that the lower-karat golds are made more tarnish-resistant by the addition of small percentages of palladium. The development of industrial uses for the platinum metals was one of the important activities of 1939. The commercial production, for uses in the chemical and process industries, of thin claddings of platinum or palladium on large sheets of base metal is one example, and platinum-clad tubing is another. Platinum alloys continue to figure prominently in the new glass fibre industry and in the chemical industry for rupture- or so-called safety-discs, particularly in equipment handling fluorine compounds or other corrosives.

In the air service, with the increase in the building of airplanes, platinum-iridium, platinum-ruthenium and platinum-rhodium contacts for magnetos have been in demand. Interest has been shown in the United States, following successful British experience, in the use of platinum electrodes for aircraft spark plugs. In the field of lighting, rhodium-surfaced reflectors, both large and small, have been more extensively used for coast and other defense equipment in ever-increasing value. In the rayon field, various plants throughout the world have introduced the use of platinum-rhodium alloy spinnerets, which in many instances replaced gold alloy spinnerets. An important step in dentistry during 1939 was the further development of the casting of platinum and iridium-platinum, making pos-

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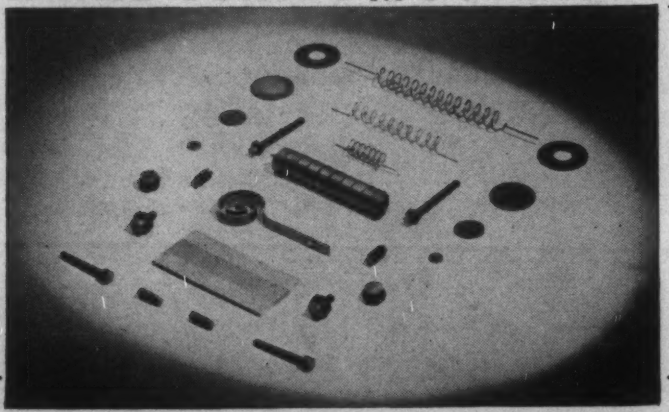

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In the jewelry field, the consumption of palladium has continued to increase, particularly in combination with yellow golds. There is also a wider acceptance of platinum for watchcases, as a result of large scale commercial production for the manufacturing trade. Progress has been made in the development of platinum-clad optical frames. Platinum leaf was made available during 1939 for outdoor signs and for interior decoration, bookbinding, etc., and has taken its place alongside palladium leaf, developed several years ago for somewhat similar purposes. The most interesting use of platinum leaf this year was on the statue, "Dawn of Tomorrow", at the New York World's Fair. (3b)

Tarnishing of Silver

Reflectivity Measurements on Silver Alloys ("Reflexionsmessungen an Silverlegierungen") Ernst Raub & Max. Engel. *Z. Metallkunde*, Vol. 31, Nov. 1939, pp. 339-344. Original research.

Binary and ternary silver alloys with beryllium, silicon and aluminum were melted in a vacuum (high frequency furnace) or in a gas furnace and cold-rolled with intermediate annealings. The sheets were tested for resistance to tarnishing in an "ordinary residence atmosphere" (one containing small amounts of sulphur dioxide and moisture) by reflectivity measurements at a 45° angle in a photometer, using a calibrated chromium and rhodium mirror as reference. The sheets were tested as-rolled, annealed and as-quenched. Four samples were used for each test, and the sheets were studied in the ground and in the polished states.

No differences were noticed between the hard-rolled and annealed samples. The differences between the ground and polished specimens were very (usually immeasurably) small. Beryllium and silicon drastically reduce the reflection ability of polished silver surfaces. Owing to the presence of hard beryllium- and silicon-rich crystals, the preparation of a uniformly smooth surface during polishing is prevented. Aluminum also cuts down the reflection power of silver, but as long as the aluminum content remains within the solubility limits of aluminum in silver, the loss is relatively small.

Beryllium and silicon retard to only a very small degree the tarnishing of polished silver; with as-rolled and ground alloys no distinct differences in the resistance towards tarnishing of silver with and without additions of beryllium or silicon could be observed. Aluminum, however, is without benefit, and, in fact, very materially reduces the tarnish-resistance of silver. The slight improvement of surface stability of polished silver accomplished through beryllium additions is destroyed if the alloy contains beryllium oxide.

The thermal treatment recommended by Price & Thomas (see *Metals and Alloys*, Vol. 10, Apr. 1939, p. 239R/8) for the production of non-tarnishing layers of pure oxides of aluminum, beryllium, and silicon on silver alloys containing these elements is called unsuitable for the commercial production of non-tarnishing silver. The recrystallization on annealing rolled silver reduces the reflection power by 10%. A further drop occurs at higher temperatures, because of grain growth. No continuous layers can be cathodically produced on silver by electrolysis of aluminum salt solutions, although such layers are capable of production from solutions of beryllium salts. The properties of oxidized layers obtained by using beryllium salt solutions depends greatly upon the acidity of the electrolyte. The commercial possibilities of the latter process for the production of non-tarnishing silver are stated to be nil.

EF (3b)

Stress Corrosion of Aluminum-magnesium Alloys

The Stress Corrosion of Wrought Aluminum - magnesium Alloys ("Untersuchungen über Spannungskorrosion von Aluminium-Magnesium-Knetlegierungen") A. Mühlenbruch & H. J. Seemann. *Z. Metallkunde*, Vol. 31, Sept. 1939, pp. 293-296; discussion, pp. 296-299. Research.

Aluminum-magnesium alloys with more than 8% magnesium are subject to "stress corrosion", *i.e.* to an accelerated corrosion attack due to the presence of mechanical stresses. Seven aluminum alloys with 7.96-9.10% Mg, 0.06-0.36 Mn, 0.02-0.35 Fe, 0.03-0.30 Si and 0-1.20 Zn were rolled to 1.1 mm. sheets, homogenized at 420° C. in a salt bath and (1) water quenched, (2) slightly heterogenized by air-cooling, or (3) considerably heterogenized by a 2-hr. anneal at 310°-340° C., *i.e.* directly below the solubility line. All samples were then slightly cold worked by rolling from the 1.1-mm. size to 1.0 mm. One set of samples was aged for 1 day at 100° C., another for 2 weeks at 75° C.

The corrosion resistance was tested in 3% sodium chloride solution in (a) spray and (b) intermittent submersion apparatus (5 min. dip, 25 min. drying period), whereby the time required for appearance of the first crack is taken as the "life". Aging at 75° and 100° C. materially reduced the "stress corrosion" resistance. The samples treated at 100° C. showed a longer life than those held at 75° C. The slightly heterogenized (air-cooled) material yielded better results in both corrosion tests than the more completely heterogenized or water-quenched samples. The superiority of the slightly heterogenized specimens was established for all alloys, including those containing zinc. No improvement specifically attributable to the presence of zinc could be found. No correlation between grain size and resistance to stress corrosion could be established.

In the discussion, Siebel confirms the suppression of stress corrosion by air cooling. It was noted, however, that an aluminum alloy with 8% magnesium and 1% zinc was more resistant to stress corrosion than the mechanically-equivalent 9% magnesium alloy, a contradiction of the authors' conclusion that zinc is without benefit. Attention is called to the same effect of "season-cracking" in brass and stainless steel. Contrary to the authors' statements, coarse-grained material was found to be less sensitive than fine-grained.

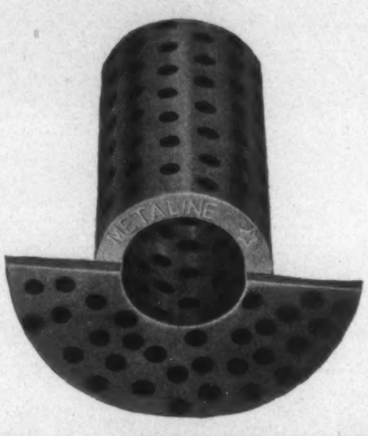
Brenner calls attention to the difference in yield point and to wide ranges of testing results in duplicate tests as an explanation for different results by various investigators. He, like the authors, could not find a beneficial effect of 0.5-1.0% zinc on stress corrosion resistance. Althoff states that tests in sodium chloride solutions and seawater do not furnish the same results. Alloy additions that stabilize the homogeneous state show promise of solving the stress corrosion problem. For instance, 1-2% copper was found to be very helpful. *Inter*crystalline disintegration is observed on cubic metallic materials, while *intra*-crystalline attack prevails in the case of hexagonal structure. EF (3b)

Thar's

METALINE

In Them

BEARINGS



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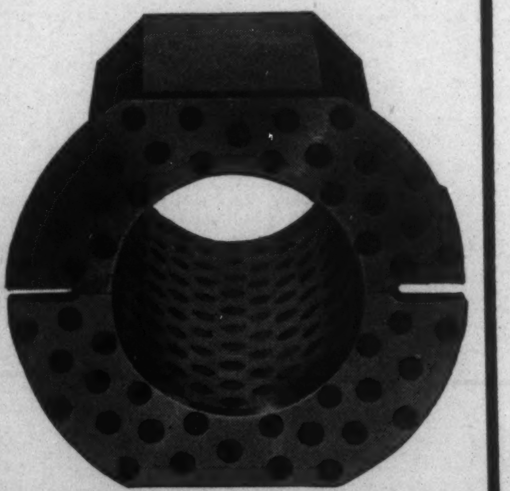

METALINE BEARINGS are made in one- and two-piece, plain or flanged, segments, flat plates, collar washers or what you will. Send for new catalogue which contains their complete story and tell us your bearing troubles. Our engineers are helpful.

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4 Testing and Control

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

Superlattices

The Formation of Binary Superstructure Phases under the Influence of Partially Soluble Additions ("Die Ausbildung binärer Überstrukturphasen unter dem Einfluss beschränkt loslicher Zusätze") Hellmut Bumm. *Z. Metallkunde*, Vol. 31, Oct. 1939, pp. 318-321. Original research.

Various gold-copper-silver alloys with the gold-copper ratio approximating the compositions AuCu and $AuCu_3$ were investigated. In these alloys a regular distribution of the gold and copper atoms occurs at low temperatures. In the AuCu type alloys, the gold atoms were partly replaced by silver atoms. In the $AuCu_3$ type alloys, the gold-copper ratio was held constant and small amounts of silver were added. X-ray pictures and electrical conductivity measurements showed that an addition as low as 5% silver prevents ordering. Larger silver additions are not completely soluble in the gold-copper solid solution; on quenching from 700° C. and annealing the alloys become heterogeneous. The hardness increases in ternary alloys of this composition have been reported by other investigators and are due to precipitation effects.

In iron-nickel alloys of the approximate composition of $FeNi_3$, no superlattice lines could be found by X-rays, although the drastic decrease of electrical resistance on annealing indicates a regular atomic distribution. The addition of copper reduces this resistance effect, it is true, but it still amounts to a decrease of 22% at 10% Cu addition. It is concluded that copper only very slightly disturbs the ordering phenomena in the $FeNi_3$ phase. On the other hand, a comparison with other highly permeable alloys shows that even very small additions of chromium, molybdenum and tungsten prevent the regular atomic distribution. EF (4)

Fatigue Tests of Wire

"Fatigue Tests of Wire." C. P. Wampler & N. J. Allewan. *Wire & Wire Products*, Vol. 14, Nov. 1939, pp. 649-653. Descriptive.

A new method of fatigue testing of wire without modifying the original surface is described, and compared with the vibratory method of load application. In the new test, made in the "rotating strut" machine, the specimen is loaded as a free-ended column, in which the bending stresses are greatest at the point of maximum deflection, *i.e.* the midpoint of the length. The application of a compressive load causes the specimen to buckle, and the deflected specimen is made to rotate about its axis of flexure. The machine can handle wire from 1/16 to 3/16 in. diam. The theory of stress calculation is given and results of tests with high-C steel and brass wires and rods are described.

The results by this and conventional vibratory methods agreed well. The surface condition had a pronounced influence in reducing the fatigue strength of the wire below the value found by testing specimens which had a carefully machined and polished surface. Straightening of the brass and soft steel rod in an operation that produced in the rod a permanent elongation of 0.1% had no appreciable effect on the fatigue strength, so that these materials can be straightened for testing in the new machine without influencing the result. Ha (4)

Precipitation in Aluminum Alloys

"The Microscopic Analysis of Intermediate Phases in Some Age-Hardening Alloys." Marie L. V. Gayler. *Proc. Roy. Soc.* [*A*], Vol. 173, Nov. 1939, pp. 83-91. Original research.

Careful microscopic examination at up to 2500 magnifications has been made for the purpose of identifying the phases precipitated during the age-hardening of aluminum alloys containing 4% Cu; 4% Cu + 0.5% Mg; and a duralumin alloy made with 99.7% pure aluminum in which no manganese is present.

In the aluminum-copper alloy, plates of a blue-gray intermediate phase (called α $CuAl_2$) were found scattered with random orientation in samples aged at temperatures up to 350° C., as well as the slightly pink constituent generally known as $CuAl_2$ (called β $CuAl_2$). The α $CuAl_2$ must originate from the copper atoms that segregate in the form of plates on the [100] planes in the early stages of aging. This intermediate constituent is always metastable, and changes to β $CuAl_2$ by a polymorphic transformation. The change is not due to a reaction between α $CuAl_2$ and aluminum, since no reaction ring is formed, and the speed of transformation is a function of the temperature.

In the aluminum-copper-magnesium alloy a buff-colored intermediate phase was detected, formed as plates parallel to the [100] planes; and still another distinct intermediate phase was found in the duralumin alloy after prolonged aging at 250° C. JCC (4)

Solubility of Iron in Aluminum

The Solubility of Iron in Aluminum ("Ueber die Löslichkeit von Eisen in Aluminium") Albert Roth. *Z. Metallkunde*, Vol. 31, Sept. 1939, pp. 299-301. Original research.

The solubility of iron in aluminum has not been accurately determined before. Eight alloys containing between 0.0019% and 0.310% Fe were prepared, and the samples were annealed for 16 hrs. at 350° C., hot rolled and cold drawn to 2.5 mm. dia. wire. The wires were homogenized for 1 week at 600° C. and then aged at 225°, 320° and 500° C. for 115, 48 and 15 hrs., respectively. Electrical conductivity determinations established that aluminum dissolves 0.01% Fe at 320° C. and about 0.02% Fe at 600° C. Under the microscope, no precipitation of $FeAl_3$ was found in homogenized samples containing less than 0.05% Fe. This agrees with earlier findings by Dix (*Proc. Am. Soc. Testing Materials*, Vol. 25, 1925, pp. 120-129).

The hard-drawn wires were aged between 50° and 500° C. and then tested for electrical conductivity. No changes were noticed in the pure aluminum wire. Evidently 0.0019% Fe and 0.002% Si do not cause any changes. The conductivity of the pure aluminum samples was not affected by varying the amount of plastic deformation (60-98%) or the annealing temperature. With iron additions of more than 0.0093%, the conductivity increases on aging at 225° C., rapidly increases to a maximum at 325° C. and then drops again. At the early stages of the precipitation of iron from the supersaturated solid solution, a distinct increase of tensile strength takes place. EF (4)

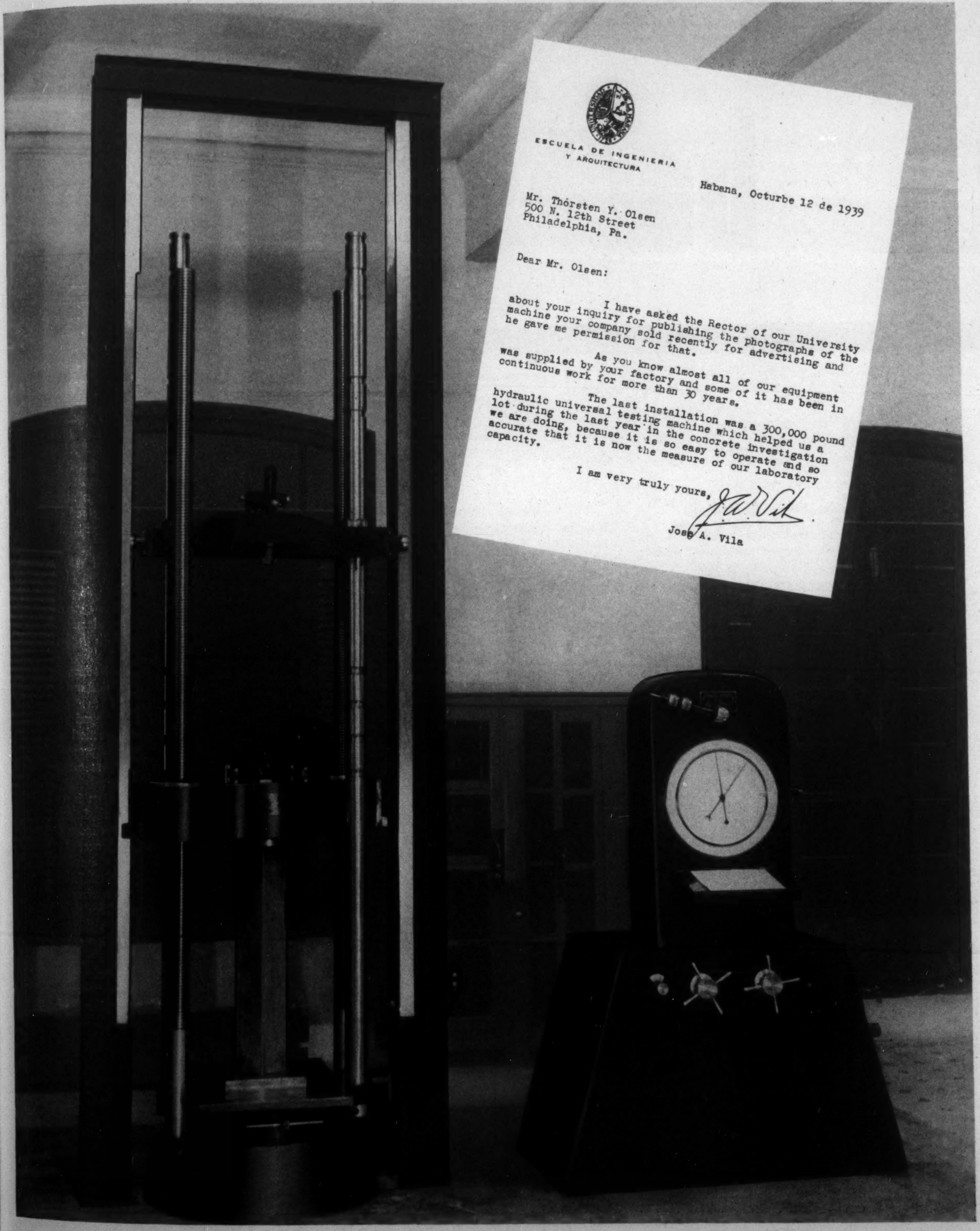
Measuring Stresses by X-rays

X-ray Measurements of Particle Size and of Internal Elastic Stresses in Cold-worked Sheets ("Röntgenographische Messung der Teilchengrösse und der verborgen elastischen Spannungen in kaltverformten Blechen") U. Dehlinger & A. Kochendorfer. *Z. Metallkunde*, Vol. 31, July 1939, pp. 231-234. Original research.

The broadening of X-ray diffraction lines in powder photographs may be due to the following causes: Minuteness of particles, slowly-changing lattice distortions or abruptly-varying lattice distortions with almost cosine-like distribution. The widening caused by particle size changes with 1/cosine of the Bragg reflection angle, the other two with the tangent of this angle. Thus; if one measures the broadening of the first lines, it is possible to determine whether the cause is small particle size or lattice distortion. The experimental technique for such studies is fully described.

Measurements on cold-rolled copper sheets showed—beginning with a 10% reduction — an effective particle size of 6×10^{-5} cm. and a lattice distortion which increases with the amount of plastic deformation. At maximum deformations, this lattice distortion amounts to 0.2% and corresponds to stresses of the order 72,000 lbs./in.^{2} EF (4)

A LABORATORY STANDARD----



ESCUELA DE INGENIERIA
Y ARQUITECTURA

Habana, Octurbe 12 de 1939

Mr. Thórsten Y. Olsen
500 N. 12th Street
Philadelphia, Pa.

Dear Mr. Olsen:

I have asked the Rector of our University about your inquiry for publishing the photographs of the machine your company sold recently for advertising and he gave me permission for that.

As you know almost all of our equipment was supplied by your factory and some of it has been in continuous work for more than 30 years.

The last installation was a 300,000 pound hydraulic universal testing machine which helped us a lot during the last year in the concrete investigation we are doing, because it is so easy to operate and so accurate that it is now the measure of our laboratory capacity.

I am very truly yours,

Jose A. Vila

TINIUS OLSEN TESTING MACHINE CO.
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books

Copper-lead Alloy Bearings

LEAD BRONZE BEARINGS. *Published by Copper Development Association, London, 1939. Paper, 6 x 8½ in., 48 pages. Free to "Those giving evidence of responsible status or genuine interest."*

This booklet is a translation of a German publication by the Deutsches Kupfer Inst., Berlin, entitled "Bleibronze als Lagerwerkstoffe." Because of a shortage of other bearing materials, copper-lead alloys are more generally used in Germany than in other countries where high-lead copper alloys find application only in severe service. A German publication on these alloys is therefore of particular interest. A good but somewhat sketchy description of leaded bronzes containing large amounts of lead is given.

The pamphlet begins by describing the properties of a bearing material. These are defined as strength and the ability to perform well when lubrication is poor, as in cases of oil supply failure and in wearing-in. The hardness should be low when cold, to equalize the load during starting, yet this hardness should not decrease so much during heating that the bearing is weak under operating conditions. The bearing should, therefore, have some property of self-lubrication.

Certain metals, such as lead and tin possess this property. Copper-lead alloys owe their usefulness to the fact that lead retains its individuality when alloyed with copper and confers bearing properties upon the copper, while the copper confers strength.

Copper-base alloys containing more than 4 per cent lead are defined as leaded bronzes, but only those alloys with 25 to 35 per cent lead are discussed thoroughly. Alloys with over 36 per cent of lead form 2 liquid layers in melting and are not extensively used commercially although uniform structures can be obtained by vigorous agitation and rapid cooling.

Tin, nickel and manganese are the usual alloying additions, with sulphur used occasionally. Tin decreases the solubility of lead in molten copper and increases hardness. Nickel is used as a hardener. It refines the grain of copper-lead-tin alloys, but in amounts of 0.15-0.30 per cent does not refine the grain of straight copper-leads. Manganese may be used as a substitute for tin. Sulphur appears to be the only element that produces grain refinement in the high-lead duplex bronzes, but if over 0.1 per cent is used, intergranular embrittlement results.

The grain refining effect of alloying additions has been greatly overestimated. The best way to obtain a finer grain size is to cool rapidly. A fine structure is stronger, particularly when the lead is spheroidal rather than dendritic. The view that a fine dendritic structure has better bearing properties is not substantiated by experience. The optimum structure is most easily obtained when the alloys are melted in coke-fired furnaces or electric furnaces. Melting in gas or oil-fired furnaces requires close supervision. A fine structure is obtained by fast cooling. For this reason green sand molds are preferable to dry sand molds, and chill casting is ideal.

Alloys containing about 30 per cent lead are usually bonded to a steel back. Various methods of obtaining a bond are described.

Copper-leads can also be produced by powder metallurgy. The usual powder metallurgy methods do not work because the lead tends to separate. One practical method involves the pressing and sintering of mixtures of copper-coated lead powders and copper powders. This method avoids the separation of lead. Bonding to copper or bronze is easy, but bonding to steel must be accomplished by an intermediate layer of tin. A better bond is obtained if the composition of the coating is graduated, with but little lead in the layer next to the steel, and high lead at the bearing surface.

The design and machining of copper leads is also discussed. Because leaded bronzes are harder than other bearing materials, they require a better finish. A single-point boring tool does the best job, and a diamond tool is ideal. Tungsten carbide is not so good, but is satisfactory for some purposes. Clearances for copper leads are 1½ thousandths per in., about twice as much as for white metals. Three thousandths per in. is not too large, but 0.8 thousandths per in. is too small, and causes seizure.—R. W. DAYTON.

Nickel Alloys

NICKEL AND ITS COMPOUNDS (Nickel und seine Verbindungen). Abegg's Handbook of Inorganic Chemistry, Vol. 4, Section 3, Part 4 (The Elements of the 8th Group of the Periodic System). *By R. Abegg, F. Auerbach and I. Koppel. Published by S. Hirzel, Leipzig, 1939. Paper, 7 x 10 in., 310 pages. Price 40 RM.*

We certainly cannot say of this subsection of Abegg's Handbook, as we said of an earlier subsection (see *Metals and Alloys*, Vol. 8, Oct. 1937, p. MA 642) that it carries too much ballast from the metallurgical viewpoint. The present volume is almost entirely metallurgical in substance and constitutes a welcome addition to the literature on nickel alloys.

Alloys and compounds of nickel with the elements of the first to sixth group of the periodic system are dealt with in 63 pages. Besides this, 67 ternary and a few quarternary alloys of nickel are covered more or less thoroughly in 50 pages, with emphasis on the commercially important alloys. The treatment of each of the nickel alloys follows—as far as literature publications are available—the same pattern: (a) Constitutional diagram, and (b) physical (and chemical) properties. For "practical and theoretical reasons" the magnetic properties of various nickel alloys are treated separately in 3 chapters totaling 64 pages.

The presentation of the subject is concise, takes liberal advantage of diagrams and tables and is aided by a short index and an exhaustive bibliography of over 1500 references published throughout the world from 1792 to 1938. With typical "Abegg thoroughness" the book summarizes our present state of knowledge, although this does not mean that each topic is discussed exhaustively. Often only the investigator or the subject of the investigation, rather than the actual findings, are referred to. The volume can thus be characterized as an up-to-date but not-too-critical reference work.—ERICH FETZ.

Other New Books

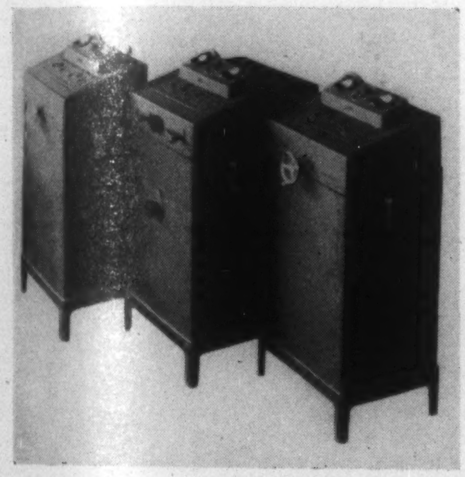
THE HANDY BOOK FOR MANUFACTURERS. *Published by Handy & Harman, New York, 1939. Loose leaf, 6 x 9 in., 91 pages. Price $1.00.* Contains information about silver, gold and platinum of special interest to silversmiths and manufacturers of jewelry and novelties, with some useful reference material for the metallurgical engineer.

IRON AND STEEL IN SCIOTO COUNTY, OHIO. *By F. H. Rowe. Published by Ohio State Archaeological & Historical Society (Vol. 10, Ohio Historical Collections). 129 pages. Price $2.00.* Chiefly historical, with interesting sidelights on the personalities and trials of the pioneers. Gives dramatic evidence of the economic changes that follow improved technology.

New Equipment and Materials

Power Source Units

The Harry W. Dietert Co., of Detroit, announces three electrical power source units for spectro-chemical analysis. These source units have been developed for it is becoming more and more apparent that in spectro-chemistry, high quantitative analytical accuracy can only be achieved by strict and convenient control of the conditions of current used to excite the sample being tested. With either of these three electrical power source units the error due to light source is at a minimum.



The unit shown on the left hand in the illustration is the 3 kw. ARL arc rectifier unit for exciting the sample with 250 volts, 4 to 14 amp., D.C. current. The unit shown in the center is the ARL high voltage spark unit for exciting the sample with 35,000 volts, 2 kw., A.C. spark current. The unit shown on the right hand is the 5 kw. high voltage arc unit for exciting the sample with 2500 volts, 2-5 amp., A.C. arc current.

Each unit is equipped with voltmeter, ammeter, automatic timer, safety relay, power control and necessary switches all mounted on an inclined switch board panel. These source units are available to work in conjunction with any type of spectrograph.

Aluminum Alloy Bearings

The Aluminum Co. of America, Pittsburgh, announces that a new aluminum alloy automotive bearing has outstanding advantages of high fatigue strength which is many times that of conventional bimetallic bearings used for the same purpose; high resistance to corrosion; and economical construction. In tests recently made, the all-aluminum bearings were shown not only to have a superior resistance to fatigue, but also were found to be satisfactory as far as friction is concerned. The aluminum bearing is claimed not difficult to fabricate and can be finished by customary methods. Use is at present limited to engines for commercial vehicles which have hardened shafts and which operate at relatively lower speeds at the bearing surfaces.

Manufacturers are invited to send to the Editor items which are suitable for this Department. Illustrations are acceptable, preferably in the form of cuts not more than 2 in. wide.

Stainless Steel Electrode

A new stainless steel known as "Stainweld D" is announced by The Lincoln Electric Co., Cleveland. "Stainweld D" should be used for arc welding stainless steel of the 25 chromium, 20 per cent nickel type, known as Iron and Steel Institute No. 310.

"Stainweld D" is also used for welding various stainless steels to mild steel and for welding of steels which are air hardening and cannot be heat treated after welding, such as both armor plate and similar steels. In general, preparation of the work and welding procedure is similar to that used in mild steel welding. Surfaces to be welded should be free from all foreign material. Slag should be thoroughly cleaned. Thin sheets should be clamped against a copper backing to maintain alignment, reduce buckling and prevent burning through.

Bending Press

The Steelweld Machinery Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio, announces the addition of Model J-12 to their line of Steelweld Bending Presses.

This press will handle plate up to 12 ft. x ½ in. between housings and up to 14 ft 0 in. over total length of bed and ram. Longer plate can be handled by extending bed and ram either on one or both ends. Like the other Steelweld presses the J-12 has a one-piece all-welded frame which will remain rigid for the life of the machine.

The ram is operated by two eccentrics, one on each side of the machine. Each eccentric is provided with three extra large main bearings and an eccentric bearing. The bearings are automatically lubricated by two oiling units mounted on either end of the machine. All gears are protected with metal covers and shafts located at rear of machine away from possible damage of crane hooks and bent-up plates. The machine is modern streamlined in appearance.

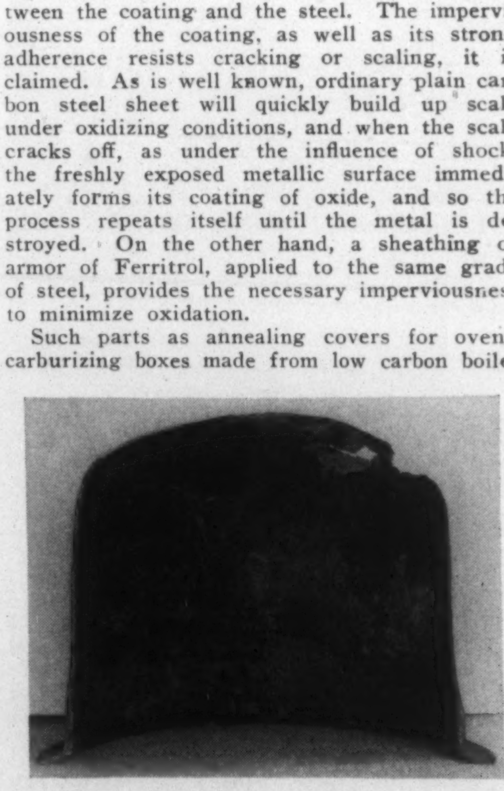
The press may be used for bending, forming, blanking, drawing, rubber-forming and multiple-punching operations. Several operations may be handled by passing the work successively through various dies set in position along the length of the machine. Approximate overall dimensions are: Length 15 ft. 6 in., depth 7 ft. 4 in., height 11 ft. 0 in. The usual deep 18-in. throat, which is standard for Steelwelds, is provided.

Prevention of Scaling at High Temperatures

An anti-sealing compound has been developed by E. F. Houghton & Co., Philadelphia, which can be applied to plain carbon steel parts subjected to high temperatures. The name is "Ferritrol."

It consists of a pigment, made up of metallic oxides especially chosen for their refractoriness, suspended in a vehicle, which also has refractory properties. When steel which has been coated with Ferritrol is exposed to high temperatures, there is a bond formed between the coating and the steel. The imperviousness of the coating, as well as its strong adherence resists cracking or scaling, it is claimed. As is well known, ordinary plain carbon steel sheet will quickly build up scale under oxidizing conditions, and when the scale cracks off, as under the influence of shock, the freshly exposed metallic surface immediately forms its coating of oxide, and so the process repeats itself until the metal is destroyed. On the other hand, a sheathing or armor of Ferritrol, applied to the same grade of steel, provides the necessary imperviousness to minimize oxidation.

Such parts as annealing covers for ovens, carburizing boxes made from low carbon boiler plate, pots of pressed steel for cyanide and other molten salt baths, pyrometer tubes and metal structural parts subject to oxidizing conditions are involved. The life of such parts, when treated with Ferritrol, is claimed to be prolonged up to 300 per cent, and thus ordinary carbon steels approach closely the life of the more expensive alloys.



Another important property of the coating, in addition to increasing materially the resistance to scaling and oxidation of the underlying metal, is its sufficient physical strength to minimize disruption of the coating under shock and other stresses to which objects such as those just listed may be normally subjected.

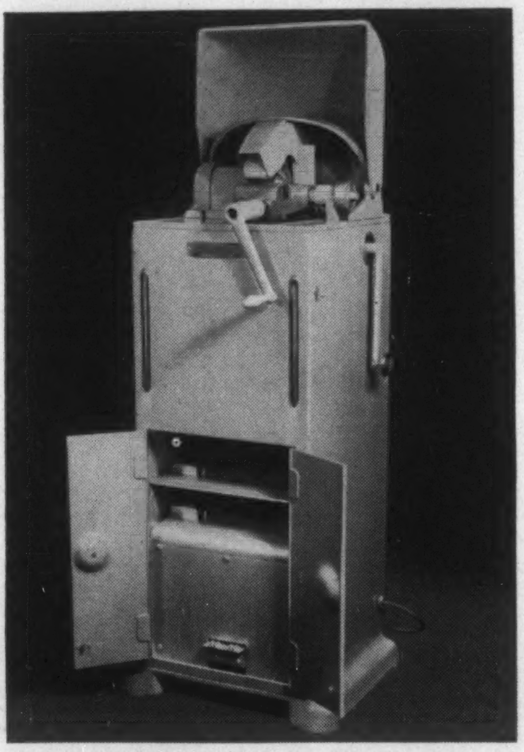
Still another claimed advantage of the coatings provided by Ferritrol, is that they are of a dark color, so that they absorb heat, thus reducing the required degree of heat and effecting high economy in the use of such coated articles.

The illustration shows the left side of a cyanide pot protected with Ferritrol. The uncoated right side scaled away.

Jarrett Specimen Cutter

Low speed submerged cutting with a rubber bonded wheel is one of the outstanding features claimed for the "Specimen Cutter" announced by Tracy C. Jarrett, Southbridge, Mass.

The 10-in. cutting wheel which operates at 6000 surface ft. per min. is only 1-16 in. thick and was developed especially for this new machine. It is said to have a high degree of efficiency and will not burn. Cut specimens are ready to be mounted in Bakelite for polishing without the need for any further surfacing. Only seconds are required for either hard or soft specimens. A double vise holds both ends of the specimen and insures a smooth, even and accurate cut. If two cuts are made upon the same piece of stock, the cut planes may be made within 0.002 in. of being parallel.



An interesting feature of this vise is that it may be raised from or lowered into the cutting well by operating a small screw, using the same handle furnished to tighten the vise. This vise is constructed of stainless steel and bronze to prevent rusting. The vise is fed into the cutting wheel by a precision rack and pinion operating a dove tail which may be tightened when necessary by jibs. The dove tail and vise construction results in an extremely sensitive feed. The two parallel jaws of this vise are at right angles to the dove tail and to the cutting edge of the wheel.

Water throw or splash is controlled by built-in splash ribs. The cutting wheel is amply protected by a heavy metal guard; and the entire cutter is enclosed in an all-steel welded cabinet, with a hinged hood which may be lowered while the cutter is in operation. The steel cabinet also contains shelves for storing extra wheels and other accessories.

Stainless steel is used in the cutoff wheel shaft and vise shafts. Heavy duty sealed ball bearings are used throughout. Motive power is furnished by a 1-hp., 3-phase, 220 v. motor placed within, and protected by the steel cabinet. This cutter in its streamlined steel cabinet is a companion piece to the Jarrett metallographic polishing machine introduced by the same maker a few months ago.

A Wear-Resistant Composite Metal

A machine which produces a new composite metal has been licensed for manufacture by the United Engineering & Foundry Co., Pittsburgh. The license has just been granted by R. E. Kinkead, consultant in welding, 3441 Lee Road, Cleveland.

An entirely new development, the composite metal which will be produced by the new machine, revolutionizes all ideas concerning wearing properties of materials and the cost of obtaining them in the many manufactured and fabricated products which require maximum resistance to wear and ordinary rust, it is claimed.

The new metal makes available—at cost savings of 15 to 20%—wearing qualities which are better and more lasting than those of competitive materials such as tin, terne and galvanized steel, it is claimed. While possessing all the advantages of such materials, plus large cost savings, the new metal has none of the disadvantages. The new material is ordinary steel with the surface alloyed by addition of chromium and nickel.

Past efforts to increase the utility and serviceability of steel have taken many forms. Mild steel has been coated with nickel, brass, copper, chromium, tin or zinc—not to mention glass, rubber, paint, lacquer and such non-metallic elements—to make it more resistant to rust. One of the most recent attempts to increase the wear resistance of ordinary mild steel has been to clad it with a thin layer of stainless steel.

While all of these materials represent advances over plain steel in the matter of wear, their availability has been restricted either by their comparatively high cost or by problems encountered in manufacturing or fabricating them into finished products.

Because it provides unsurpassed wearing qualities at substantial cost savings, the new metal is claimed tremendously significant not only to the steel industry but to manufacturers and users of products in the almost unlimited field where the benefits of the new metal will be clearly apparent.

Advantages of the new metal, particularly its long service life and low cost, will affect such products as: Rain spouting, stoves, heating equipment, cooking utensils, plumbing fixtures, washing machines, sinks, bath tubs, heat piping, milk pails, dairy plant machinery and equipment, farming utensils, food making equipment, candy manufacturing machines, chemical plant equipment, paint making machinery, ships and boats of all types, automotive parts, airplane structures, railroad equipment, tanks and containers, water pipe, many types of machinery such as pumps, equipment for the manufacture of rubber, leather and textiles, as well as many other items whose maximum utility and service life is dependent upon resistance to rust and other destructive agents.

Capable of being made in thicknesses comparable with paper—0.010 in.—the new metal can be produced within predetermined specifications. The process is also claimed controllable for production of various alloys. Pickling, shot blasting, cold reduction, polishing or other operations may be carried out at costs which are customary with ordinary materials.

The new machine, which makes possible the production of this new composite metal, and which has just been licensed for manufacture, utilizes the Lincoln "Electronic Tornado" process of automatic carbon arc welding.

High Strength Filter Paper

The Enthone Co., 442 Elm St., New Haven, Conn., has announced the sale of a new high strength paper for filter presses, which is claimed to possess the highest wet strength of any paper on the market for this purpose. The paper possesses exceptionally long fibres, and in addition has been given a patented wet strength treatment.

The paper, costing less than a cent a sheet, is placed against the filtering canvas or screen and the filter cake deposits upon the paper, thus enabling rapid cleaning of the canvas by merely removing the filter paper carrying away the filtrate. It is stated that the high strength of the paper, both wet and dry, obviates any danger in tearing, both in placing the paper and removing it from the canvas. The paper being only a few mils thick, allows tight locking of the plates and frames to prevent leakage. The paper is fast filtering and tests by the supplier has shown it to possess high strength in acid solutions with pH values as low as 2.0 and in strong caustic solutions up to 15 oz. per gal. of caustic soda.

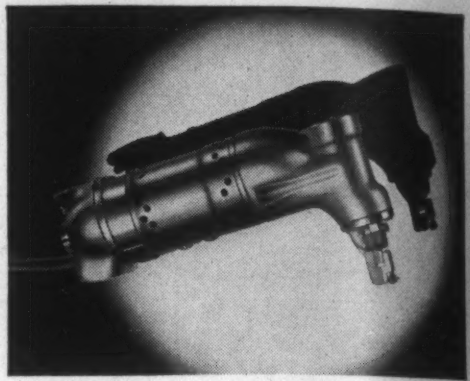
Some of the advantages claimed for the use of this paper are: Fast cleaning of filter presses, more thorough filtration, longer life of canvas, and tight sealing of plates and frames.

Samples and literature can be secured by writing the manufacturer for Bulletin No. 55 stating the make and plate size of the filter press.

Portable Electric Nibbler

A small, portable electric Nibbler for cutting all kinds of sheet metal has been introduced by the Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago. Only 9 in. long and weighing but 3¾ lbs., it is a compact tool with a yoke type front head incorporating a punch and die that "nibbles" out a rectangular shaving of metal at each upward stroke of the punch. The "Thor Nibbler" will cut up to No. 18 gage (0.049 in.) in steel and up to No. 15 gage (0.072 in.) in aluminum.

In addition to any work that can be done with the ordinary portable electric shear, the new Thor Nibbler, because it cuts its own clearance, will cut wide strips without distorting or curling the sheet even if the sheet is corrugated or has a curved outline. Internal cuts of any shape may be made without breaking-in from the edge of the stock, simply by drilling or punching a hole 1 in. in diameter and inserting the head of the tool in this hole. Curves and circles with as small a radius as 1 in. can be cut. Shapes can be cut out of tubing that is as small as 1½ in. in diameter.



The 2½-in. diameter motor housing of the Nibbler serves as the handle of the tool to give positive control and leave the other hand of the operator free for manipulating the work. The cutting punch of the Nibbler is recessed in such a manner that too much stock cannot possibly be fed to the cutting edge. The front head can be loosened and turned to either right or left and set at an angle of 30 or 90 deg. when space limitations make it desirable to cut at an angle to the machine. Its small size, light weight, speed and power make it suitable for both shop production and on-the-job installation work. Further information on the uses and construction of the Thor Nibbler may be had by writing to the company for Bulletin No. E-31.

Castolin for Welding

A new welding material, named "Castolin," has just been introduced on the American market. It comes in a variety of alloys and fluxes for oxy-acetylene welding and has one great claimed advantage over similar products previously obtainable—welding can be performed at unusually low temperatures. Due to the low temperatures at which welding can be made with Castolin alloys, overheating and subsequent warping of welded parts is voided; stresses are eliminated. A great many welding jobs which heretofore were almost impossible are now accomplished without difficulty, it is said. In repair work the low temperature at which binding occurs makes it unnecessary to preheat for long hours parts to be repaired. Alloys for the steel, aluminum, brass and bronze industries are now available. Outstanding among Castolin alloys are:

Castolin 190 for welding of aluminum and its alloys, even in the form of very thin sheets. Castolin 185, also called "Bronzechrome," for building up on steel, cast iron, copper, brass, bronze, etc.

Other alloys available are No. 14 for cast iron, binds at 900 deg. F.; No. 15 for cast iron, binds at 360 deg.; No. 16 for steel, binds at 1470 deg. F.; No. 18 for copper, brass, extruded bronze, binds at 1600 deg. F., and is poreless; No. 210 for cast aluminum, binds at 950 deg. F.; No. 195 for die casting (white metal), binds at 750 deg. F.

The above Castolin alloys and others are described in Pamphlet C-60, issued by Park Sales Co., 3 Park Place, New York City.

(Continued on page MA 118)

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The 48-page book, "A.W." Presents Dyn-el, gives full details of savings in weight and cost possible with this new high-strength, flat-rolled steel. Write for a copy.

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MAIN OFFICE AND MILLS, CONSHOHOCKEN, PENNA. : : SINCE 1826 : : DISTRICT OFFICES AND REPRESENTATIVES—Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, St. Paul, Pittsburgh, Roanoke, Sanford, N.C., St. Louis, Los Angeles, San Francisco, Seattle, Montreal—A. C. Leslie & Co. PRODUCTS INCLUDE—Steel Products in Carbon, Copper or Alloy Analyses : : Sheared Steel Plates : : Hot Rolled Sheets and Strip : : "A.W." Rolled Steel Floor Plates : : Billets, Blooms and Slabs : : "Swede" Pig Iron : : Reading Cut Nails.

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Liquid Heat N.D.

Melting Point 1200°F. — Working Range 1300-1700°F. For hardening tools, reheating carburized work; for general hardening of parts prefinished to size, on which there are no further operations. Also used as a pre-heat for high speed steel treatment.

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Melting Point 980°F. — Working Range 1100-1500°F. For tool hardening and production reheating.

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Melting Point 1040°F. — Working Range 1100-1700°F. Especially adapted for hardening medium carbon steel parts or carburized parts ground after hardening. Higher fluidity at working temperatures.

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Write for specific recommendations for your work, or ask the Houghton Man.

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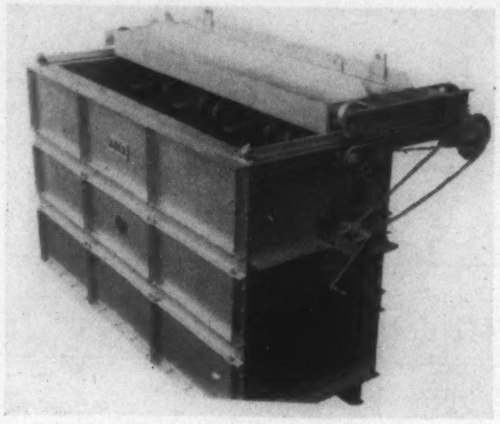
- PHILADELPHIA -

Chicago Detroit

Electric Salt Bath for Aluminum Alloys

The Ajax-Hultgren heating principle, now widely used in salt baths for carburizing, hardening, and the treatment of high speed steel tools, has now been applied commercially to large nitrate baths for the heat treatment of aluminum alloys.

The illustration shows a unit in which the pot measures 84 in. long, 24 in. wide, 46 in. deep. The three pair of electrodes arranged along the back wall of the pot eliminate the need of any heating elements, since the heat is generated directly in the salt bath by virtue of its resistance to the flow of current between the narrow electrode gaps.



The electrodes are so arranged and proportioned as to produce an automatic circulation of the bath by means of electromagnetic forces generated at the electrodes. This patented operating principle is said to assure extreme uniformity of temperatures throughout the pot contents, and virtual elimination of any maintenance expense, since no heating element replacements are necessary.

The furnace has a working temperature range from 450 to 1100 deg. F. covering the annealing and precipitation hardening of all aluminum alloys such as sheet, stampings, structural shapes, castings and forgings.

"Pylumin"—for Aluminum Surfaces

The metal finishing laboratories of the Pyrene Mfg. Co., 562 Belmont Ave., Newark, N. J., announce that they have developed a simple process for the treatment of aluminum. Like the familiar Bonderizing process for steel, the new process, which has been given the name "Pylumin," is claimed equally efficient for the protection of aluminum and for its preparation for paints and enamels. It is recognized, it is said, that owing to the nature of aluminum and its alloys, the untreated surfaces possess no natural affinity for paint, lacquer or enamel coatings.

The new process, Pylumin, is claimed to combine all of the following advantages: Simplicity and economy of operation, inexpensive equipment, adaptability, flexibility, protection and appearance. It is said to have been successfully used on a wide variety of parts such as microphones, transmitters, switch boxes, lamps, fishing reels, clock and radio parts, etc.

Protective Compound for Stainless Steel

A new metal protecting compound to be used in conjunction with ordinary wrapping paper for the protection of stainless steel sheets and materials during storage, fabrication and shipping has been announced by Paisley Products, Inc., 1770 Canalport Ave., Chicago, and 630 W. 51st St., New York City.

According to the manufacturer, this new compound is brushed on the metal and the paper is spread over the coating. Or the paper may be coated and smoothed onto the metal. It is claimed the paper will lay perfectly smooth, effectively protecting the metal against abrasion and scratches during handling, and that the flat paper covering affords an excellent surface for lay-out work.

To remove the paper and compound, the manufacturer states, simply wash off with warm water. The compound is available in containers ranging from quart size to 55 gallon drums.

Electric Salt Bath Furnace

The Upton Electric Salt Bath Furnace is capable of doing practically any heat-treating operation involving temperatures from 250 to 2500 deg. F., it is claimed. It can also be used as a heating device for brazing assemblies, heating before forging, or similar heating operations. This furnace is the result of 8 yrs. of painstaking research by R. C. Upton of Detroit, and associates, most of which was conducted on the hardening of high speed steel, the most difficult of all heat treating operations.

The Upton furnace operates on the principle of "Continuous Electric Current Flow," the rate of which varies instantaneously to offset temperature fluctuations. Temperatures can be maintained up to 2500 deg. F. with accuracies within the limits of pyrometric measurements; in other words, the furnace itself is a pyrometer calling for or refusing electric power as the temperature fluctuations dictate. It might be compared with an internally fired fuel furnace with 3000 burners which are continually lighting or going out as the demand for the heat prescribes.

The ceramic lining of this pot is said to withstand temperatures in excess of those demanded by the heat treater. The construction of the pot permits a greater power input to the bottom of the pot. This "hot bottom" creates strong convection currents which distribute the heat evenly throughout the entire bath. The furnace is manufactured by the Commerce Pattern Foundry & Machine Co., Detroit.

A Dual-Time Weld Timer

The "Dual-Time" timer, a single welding timer accurately controlling two spot welding guns at the same time through a single transformer, permitting four separate welding operations without changing the timer setting is announced by Weltronic Corp., 2832 E. Grand Blvd., Detroit.

Of the electronic tube type, the new timer is provided with two separate time control dials for adjusting the weld time for each gun. Each gun being provided with two control buttons, the operator can, after the timer has once been set, make the proper time selection merely by pressing the proper button for the work to be welded. Thus, each gun may be used alternately as required for two different materials without further change.

Another advantage of the new timer is the fact that a dual-purpose welding gun set-up can be made with a single gun—the timer making it possible to add the second gun when needed without necessitating extensive changes and the purchase of additional transformer, pressure booster, etc.

Available for 110, 220 or 440 volt operation, the new Timer, to be known as Model 58-B, has a frequency range of 1 to 30 cycles in even one cycle steps. The timer is panel mounted and enclosed in a swing cover case with wiring diagram. Additional details, information as to price, etc., are available from the company direct.

New Alloy Rustproof Fish Hook

A manufacturer of fish hooks, Bill DeWitt Baits, Auburn, N. Y., has announced a development, which anglers of all kinds and especially those whose preference turns to salt water fishing, regard as one of the most interesting the hook and bait industry has witnessed in many years.

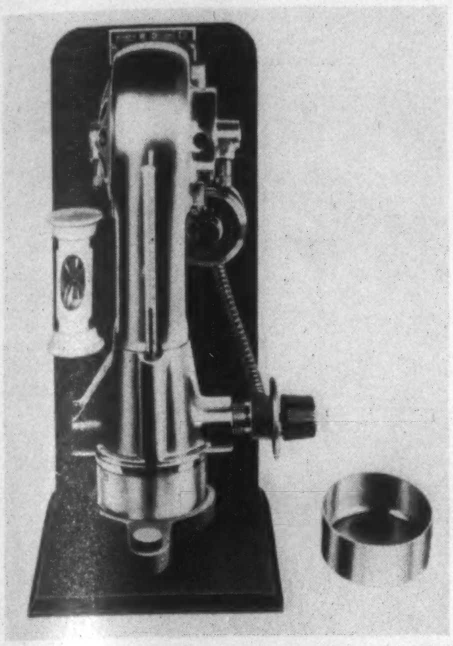
This is the production on a commercial basis of a rustproof hook with steel-like strength made of "Z" nickel, a new heat-treatable alloy containing approximately 98 per cent nickel. Introduction of the hook follows metallurgical research covering several years and manufacturing studies of many months, both in this country and abroad, where experimental production previously had indicated the practical value of the alloy for this purpose.

Corrosion protection in salt water in the past chiefly has been limited to plated or otherwise coated hooks. The materials which were able to withstand sea water corrosion adequately for the most part failed to provide the physical properties required in hooks. Corrosion resistance of the new hooks extends all the way through the metal and is not limited to surface protection.

A Moisture Teller

The Harry W. Dietert Co., Detroit, has added a new size "Moisture Teller" to its line of moisture tellers. The new addition is a moisture teller that takes a sample pan 2¾ in. in dia. and 1¼ in. in depth.

The bottom of the sample pan is made of 500 mesh monel filter cloth. The sample pan containing the sample to be dried, is placed under the heated air outlet of the Moisture Teller. The air being above the steaming point of water causes the moisture contained in the sample to be flashed to steam and blown through the bottom of the pan. The sample is dried to constant weight in as short a period as 1 min. for many materials.

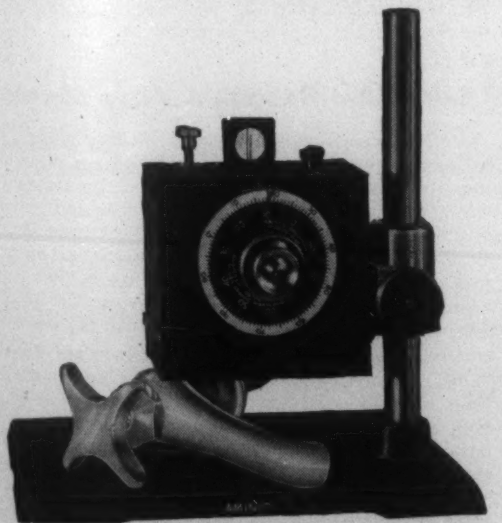


The pan containing the sample is light and may be weighed on a sensitive analytical balance for accurate moisture determinations.

The temperature of the drying air is automatically controlled by means of an adjustable thermostat. A descriptive leaflet may be obtained from the manufacturer.

A Coating Thickness Tester

The "Aminco-Brenner Magne-Gage," an instrument for measuring local thickness of coatings on metals by the rapid, non-destructive magnetic method, has been improved since its introduction in 1937. The improvement, which greatly increases the utility of the instrument, now make it possible to measure various types and thicknesses of coating with only one instrument simply by interchanging different types of magnets, it is said. The instrument as now marketed will measure (1) nickel coatings on non-magnetic base metals; (2) non-magnetic, metallic or organic coatings on magnetic base metals; (3) nickel coatings on iron or steel.



The method is simple, rapid, non-destructive of the coating or the base metal, and is especially advantageous for both works control and acceptance testing, since it permits testing of a large number of specimens at low cost.

The improved instrument is fully described in new bulletin MA2070, which may be had on application to the manufacturer, the American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.

A Hard-Facing Rod

Haynes "93" hard-facing rod, a new alloy welding rod for hard-surfacing wearing parts, has been anounced by Haynes Stellite Co., unit of Union Carbide and Carbon Corp., New York. It is recommended for use where severe abrasion, accompanied by only a moderate amount of impact, is encountered. It has already proved successful on dredge pump impellers, cement clinker crusher rolls, slag crusher roll teeth, cinder crusher rolls, tamper feet for cinder block manufacturing, tube bending mandrels, farm implements, and other wearing parts.

The new alloy rod does not possess as high wear resistance as Haystellite cast tungsten carbide products or Haynes Stellite alloys. It is, on the other hand, more wear-resistant but not as tough as Hascrome hard-facing alloy. It thus enables the Stellite company to offer an even more complete line of hard-facing materials ranging from the toughest, most impact-resistant, to the hardest, most wear-resistant types.

Haynes "93" alloy rod is of a ferrous composition and contains chromium, molybdenum, cobalt, and other alloying elements to the extent of more than 40 per cent. It has a tensile strength of about 43,000 lbs. per sq. in. and a hardness, as-deposited by oxy-acetylene welding, of 62 Rockwell C. When deposits are heat-treated by heating to 1,950 deg. F., and then air-cooling, the hardness reaches 66 to 67 Rockwell C.

Application of Haynes "93" alloy rod is described as relatively simple. It can be applied by either the oxy-acetylene or the metallic arc process. It is readily handled under the oxy-acetylene flame with a slightly carburizing (excess acetylene) flame. When the new rod is applied by the metallic arc process, reversed polarity is used, and flux-coated rods are recommended. Haynes "93" rod is available from Haynes Stellite Co., Kokomo, Ind., and from resellers everywhere.

Rubber-Lined, Nickel Plated Tanks

The B. F. Goodrich Co., Akron, Ohio, which has been a leader in the field of tank linings since its Vulcalock process of adhering rubber to metal was introduced some 15 years ago, announces a new addition to its tank lining products, known as Triflex "K" and designed especially for bright nickel plating.

Within recent years, advances in the plating industry have changed the majority of nickel plating from the regular gray nickel to "bright nickel" plating, and this has brought new problems to the manufacturer of rubber linings. "Bright nickel" baths are not only thrown more easily off balance by contamination from traces of foreign matter, but are operated under conditions much less favorable to long life of tank linings.

Temperatures in "bright nickel" plating are commonly from 140 to 160 deg. F., whereas gray or nickel baths are operated at room temperatures. Most of the bright nickel processes require the addition of organic chemicals of extreme penetrating power, known as "wetting agents" or "anti-pitters," and ordinary rubber linings have been known to slough off in bright nickel service, due to the wetting agent penetrating, swelling and loosening the ordinary top layer of rubber. This has been a frequent source of trouble, as pieces of slimy material are liable to get on the parts being plated, causing defective work.

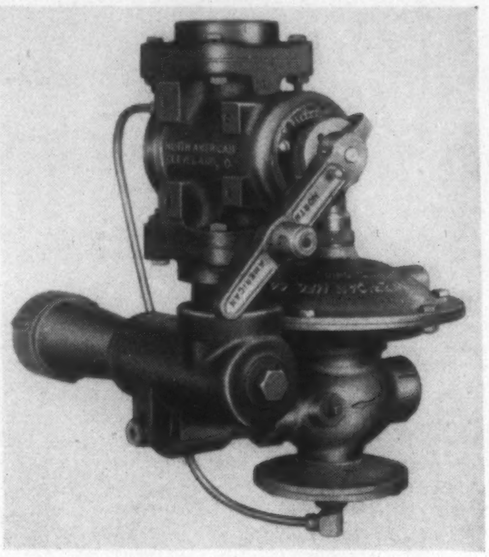
Technicians in the Goodrich research laboratories have been working intensively for several years to develop a rubber lining for bright nickel which completely eliminates such difficulties. Triflex "K" tank lining is the result of this research, and has been tested and recommended by leading manufacturers of bright nickel solutions. In addition to the laboratory research program, an extensive series of field tests were carried out, and favorable results achieved in every case.

The new lining is applied to steel tanks by the exclusive Goodrich Vulcalock process, insuring a firm bond even at elevated temperatures. Applications are made either at the factory or in the field.

The Air-Gas Ratiotrol

The new North American "Air-Gas Ratiotrol," for control motor operation is announced by the North American Mfg. Co., 2910 E. 75th St., Cleveland.

Constant proportion of the Air-gas mixture is claimed obtained by this device, insuring a constant, even heat which gives better furnace operation. It is possible to make corrections for capacities, varying pipe resistances, etc., without altering the installation itself. By means of an adjustable port all possible overriding of temperatures at low temperature setings is claimed eliminated.



"Top Hat" Annealing Furnace

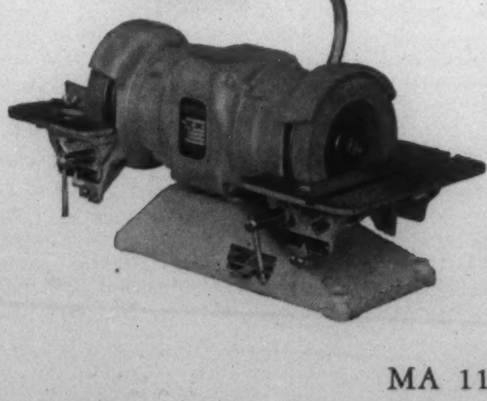
Continental Industrial Engineers, Inc., Chicago, have put out an annealing furnace which has been given the name, "Top Hat Furnace"—"as sophisticated as a Top Hat and as useful and dependable as an Old Felt."

With its radiant wall, covered from top to bottom with continuous "heat rings," it is described as giving unequalled heat distribution with glowing refractories covering the entire walls. A center radiant well permits "heating from the inside out" where advisable. Temperature variation is said to be held to the accuracy of the best control instruments.

Low priced gas fuel with all-over heat blanket and flexible range of fuel input gives economical operation, it is claimed. One ton or 5 tons, 700 or 1800 deg.—just push the button and set the controller. The furnace is available in various sizes, shapes, heights and diameters with regular or circulating fan bases. The furnace is claimed to come up to temperature in a uniform rush, and to level off in a fine controlled soak.

Carbide Tool Grinder

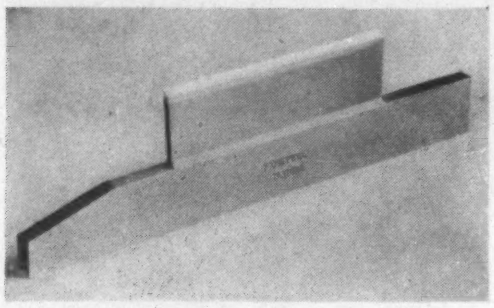
The Baldor Electric Co., St. Louis, announces the development of a new carbide tool grinder. According to the manufacturer this grinder operates with a minimum amount of vibration as it has a heavier and shorter shaft. A second improvement claimed by the manufacturer is that the armature has no end play in either direction, which permits finer grinding. For further details write the manufacturer for bulletin No. 72.



Centerless Grinder Blades

Centerless grinder rests for any type of machine or grinding operation, faced with a tough, slow wearing alloy, are obtainable from Fansteel Metallurgical Corp., North Chicago, Ill.

The hard facing, Tantung, is a patented Fansteel alloy composed of hard particles of tantalum and tungsten carbide, uniformly distributed and firmly embedded in a strong, tough matrix. Tantung differs from conventional hard facing materials in that the presence of tantalum carbide not only contributes to hardness, but imparts a peculiar lubricating characteristic which improves resistance to wear. The alloy successfully withstands the severe service of centerless grinding operations, outlasting the hardest types of steel blades by a wide margin.



The Tantung facing, which is made in bar form, is firmly affixed to the steel supports by a special brazing process perfected in the Fansteel plant. Complete blades are manufactured to specification, Tantung facing is applied to existing blades furnished by users, or Tantung bars are obtainable for those equipped to do their own brazing.

Worn out blades can be reclaimed by application of Tantung facings, and when the Tantung facing itself finally wears out, a new facing can be applied, thus giving grinder blades indefinite life.

Bonded Metals—Ni-Al and Cr-Al

On the market for the first time—and of keen interest to practically every branch of industry—are two new pre-finished bonded metals which combine the beauty and durability of nickel and chromium with the lightness, strength and workability of aluminum. These two plated metals are "Nickel-Aluminum" and "Chrome-Aluminum," just introduced by the manufacturer, the American Nickeloid Co., Peru, Ill. These two metals are formed by a surface of chromium or nickel bonded by an electrolytic process to an aluminum base metal, using the Krome Alume process patent No. 1,971,761. Previous attempts to plate aluminum involved complicated dips and the results were never reliable, it is claimed.

From exhaustive tests conducted over a period of 4 yrs. by the American Nickeloid Co., they are satisfied that this process does produce coatings that can be fabricated with positive assurance that they will not peel.

The two new pre-finished metals are available in sheets in sizes up to 36 by 96 in., in a full range of tempers, and in gages from 0.010 up to 0.064 in. A choice of bright or satin finish and striped, crimped, or currugated patterns adapts the new pre-finished metals to many uses and designs.

The manufacturer reports that both metals are easily workable during the manufacturing process, and are highly resistant to corrosion, rust, or tarnish. They can be bent, stamped or moderately drawn without damage to the permanently bonded coatings that are guaranteed not to lift or peel from the base metal. They are all-white metals, which adds to their range of commercial uses.

The company states that it will gladly send test sheets to interested manufacturers, or will send their new folder describing these new metals and containing actual samples of the new products, if inquirer will request them on his business letterhead.

"Pluramelt"—New Steel Process

In no branch of metal fabrication has there been more effort made than in that of combining the new and expensive "stainless steels" with the cheaper and stronger carbon steels. The chemical industry, the petroleum industry, the food and beverage industry, the paper industry—all use vessels that require strength against the pressures carried, and resistance to corrosive liquids or gases. High pressures sometimes demand wall thicknesses of two inches or even more of strong steel, yet only the inner surface of this must resist the corrosive contents. It seems extravagant to make a vessel of solid stainless steel when a thin layer of stainless over a plate of medium carbon steel would serve just as well.

Considerable progress has been made and many difficulties have been overcome in the production of stainless clad materials. More success has been achieved by the method of placing a thin sheet of stainless upon a steel plate of proper thickness and then spot welding them together on close centers by electrical resistance methods.

Robert K. Hopkins, as director of metallurgical research for the M. W. Kellogg Co. of Jersey City, N. J., was convinced that in order to obtain a material that would fulfill the requirements of the petroleum industry for pressure vessels such as his firm manufactures, it would be necessary to depart radically from all previously conceived methods and that the desired result could be accomplished only by the development of a new melting technique. Research was started and a thorough investigation was made of all known melting processes.

It was found that ingots produced by all of the present-day steel making processes have certain characteristics in common. Each ingot is formed from the freezing of a melt of single composition so that the final ingot is of relatively uniform composition throughout. Because of the singleness of composition of ingots produced by these well-known methods, these processes could be termed "monomelt." In the production of clad materials, it was, therefore, essential that both component analyses be, at least in part, molten at the same time, in order to secure absolute metallic continuity. Such a process could evidently be described by the words "Plural melting" or simply "pluramelt."

After intensive investigation, this result was accomplished by means of a special type of electric arc melting furnace so designed that the melting operation could be carried on and the final product would be intermelted with any other metal part and allowed to solidify as an inseparable portion of the unit mass.

Long association with Allegheny Ludlum Steel Corp. and recognition of their experience in the production of stainless steels, prompted Mr. Hopkins to discuss the problem with the Allegheny Ludlum research staff and as a result the steel company decided to participate in the further development. This work culminated in the construction of a plant at Brackenridge, Pa., which is now in commercial operation under exclusive license from The M. W. Kellogg Company under the Hopkins patents.

Pluramelt in its numerous analyses is the product of an electric furnace melting technique, as a result of which all of the special composition materials and a small part of the low-cost materials are melted and integrally joined during this operation. The furnace proper is radically different from the conventional type of electric furnace, in that the functions of steel making and of the mold are combined. In this way special steels are melted and joined to low-cost steels in ingot form, thus producing Pluramelt ingots.

High Magnesia Refractory for Furnaces

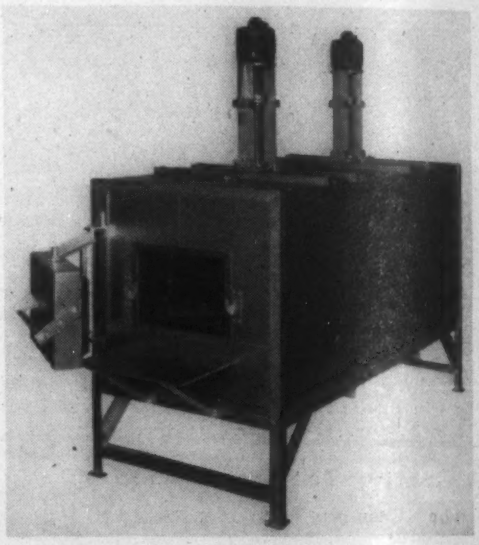
"Ramix" is put out by Basic Dolomite, Inc., Cleveland, as a new high magnesia cold ramming refractory for furnaces. It is a prepared magnesite refractory which, when mixed with water and rammed into place, is claimed to air-set to a dense, monolithic mass and, under furnace-operating temperatures, to develop great resistance to slag and metal penetration, chemical attack and erosion. Ramix is a bulk refractory, designed for use in basic open-hearth or electric furnaces and in copper, lead, brass, nickel and other non-ferrous furnaces.

As a quick, cold-patch material for major repairs to slopes, sidewalls, bottoms and foundation walls, the new material is claimed to cut "delay time," to save labor and materials, and to eliminate expensive brickwork. It is pointed to as a complete working hearth refractory for basic electric and non-ferrous furnaces and as a sub-hearth material for the basic open-hearth.

Furnace for Tempering Shafts

Cooley Electric Manufacturing Corporation, Indianapolis, Ind., has developed an electric furnace specifically adapted to the tempering and straightening of shafts. This furnace is built in two sizes, 18 in. wide by 68 in. long by 13 in. high, and 18 in. wide by 30 in. long by 13 in. high,, the larger of the two sizes being shown in the illustration. The furnaces are suitable for service up to 1200 deg. F. and are lined throughout with stainless steel. Ample circulation of the chamber air is provided by nickel-chromium alloy fans located at the top of the furnace chamber and driven by ½ h.p. motors. The heating elements are located in the bottom of the furnace and are of the Cooley embedded type in which the resistors are well protected against oil fumes, etc., usually encountered.

Two shelves are provided for holding the work, one at hearth level, the other in an intermediate position in the chamber. The furnaces are arranged for 3-phase, 230-volt service, and have an installed capacity of 30 kw. and 15 kw., respectively. In the larger furnace the elements are arranged in two zones of control, each zone being furnished with switches for reduced input operation. The smaller furnace is arranged similarly for reduced input, but includes only one zone of control.



The furnaces have been found exceptionally suitable, it is said, where shafts must be removed from the furnace individually as the direction of air circulation is such that opening of the door has little effect on the chamber temperatures. The door is of the swinging type and is simple and practical. Unusual temperature uniformity is obtained through all portions of the furnace chamber.

Corrosion-Resistant Alloy Sheet

Rolled sheets and plates of Hastelloy alloy C, a corrosion-resistant nickel-molybdenum-chromium-iron alloy, can now be furnished by Haynes Stellite Co., a unit of Union Carbide and Carbon Corp., New York. Until a short time ago, this alloy was commercially available as castings only. Now plates weighing up to 100 lb. each can be made, and the alloy can be produced in practically any commercial thickness.

Advantages claimed for this alloy are that it effectively withstands strong oxidizing agents such as acid solutions of ferric or cupric salts, and aqueous solutions containing chlorine or hypochlorites. It is one of the few metallic materials that will withstand the corrosive action of wet chlorine—at room temperature, its rate of penetration in water-saturated chlorine vapor is only 0.038 in. per yr. Hastelloy alloy C also has good resistance to hydrochloric acid up to 50 deg. C. and to sulphuric acid at temperatures up to 70 deg. C. if the concentration is over 50 per cent, or up to boiling if the concentration is under 50 per cent.

In rolled form, the alloy has a tensile strength in excess of 75,000 lbs. per sq. in., and an elongation and reduction of area of about 15 per cent. These good physical properties, coupled with the alloy's outstanding resistance to corrosive chemicals, make it an engineering material of unusual interest, it is claimed.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

A Digest of Important Developments in the World of Metals

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1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

5. General

Articles pertinent to more than one of the previous sections.

1 Production
OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

Forged Rolls

PRODUCTION OF FORGED ROLLS FOR COLD ROLLING ("Geschmiedete Arbeitswalzen für Kaltwalzwerke und ihre Herstellung") R. SCHERER. *Stahl u. Eisen*, Vol. 59, Oct. 5, 1939, pp. 1105-1111. Practical.

The recent increase in cold rolling and the use of generally higher roll pressures has focussed attention on roll failures. Formerly cold rolls were cast but lately forgings have come into use. The composition most frequently employed is 0.9% carbon and 1.8% chromium.

For long life care must be taken in the grinding and polishing as well as in the alloying, melting and forging. Sharp changes in section must be avoided and gradual fillets used. Experience has shown that rolls not bored for water cooling have longer life, but are harder to produce. Defects such as flakes, fissures, sand seams and grinding checks are illustrated. In water quenching care must be taken to avoid troostite formation at the surface and to obtain a gradual transition from the hard surface to the softer center. In grinding care is necessary to avoid local overheating.

During rolling damage may be caused by dragging or sliding of the work and too high roll pressures, which may soften the surface and cause spalling and cracking.

SE (1)

Principles of Alloying

GENERAL PRINCIPLES APPLICABLE TO THE PREPARATION OF ALLOYS BY MELTING ("Principes Géneraux Applicables a la Preparation des Alliages par Fusion") A. PORTEVIN. *Rev. Met.*, Vol. 36, Oct. 1939, pp. 429-445. Excellent general review.

Among the factors considered are the primary materials (virgin metals, scrap, master alloys, additions), method of heating (combustion, electric), atmospheres (those causing no chemical change—inert gas, atmosphere in equilibrium with melt, vacuum, protective slag; those causing chemical change such as oxidation; those purifying by decantation, coagulation of impurities, filtration, or extraction by slag), and containers. The degree of permissible superheating above the melting point is limited by volatilization, as well as by chemical factors such as reaction of the melt with the atmosphere, slag, and container.

Additions to the melt include the con-

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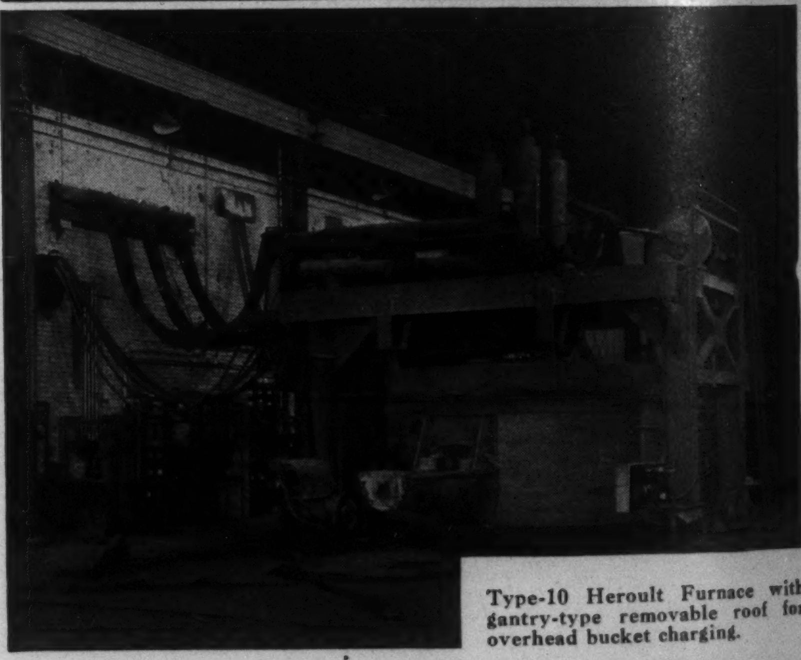

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TUBE ANNEALING

CONTINUOUS ROLLER BOTTOM TUBE ANNEALING, PENNSYLVANIA INDUSTRIAL ENGINEERS

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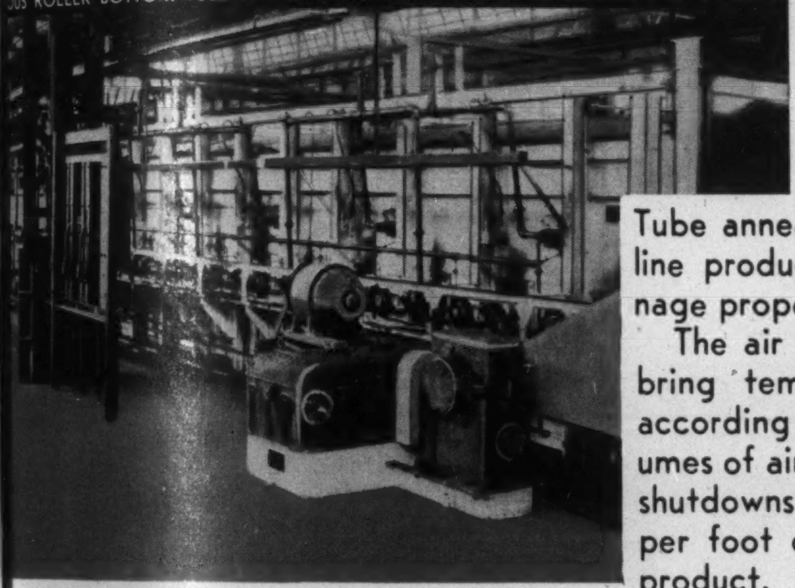

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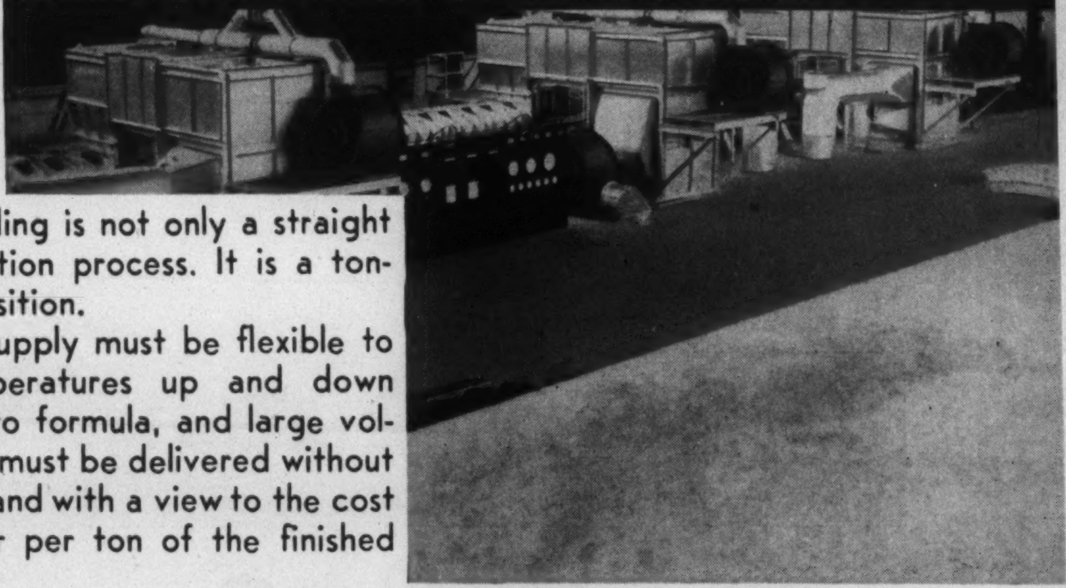

Tube annealing is not only a straight line production process. It is a tonnage proposition.

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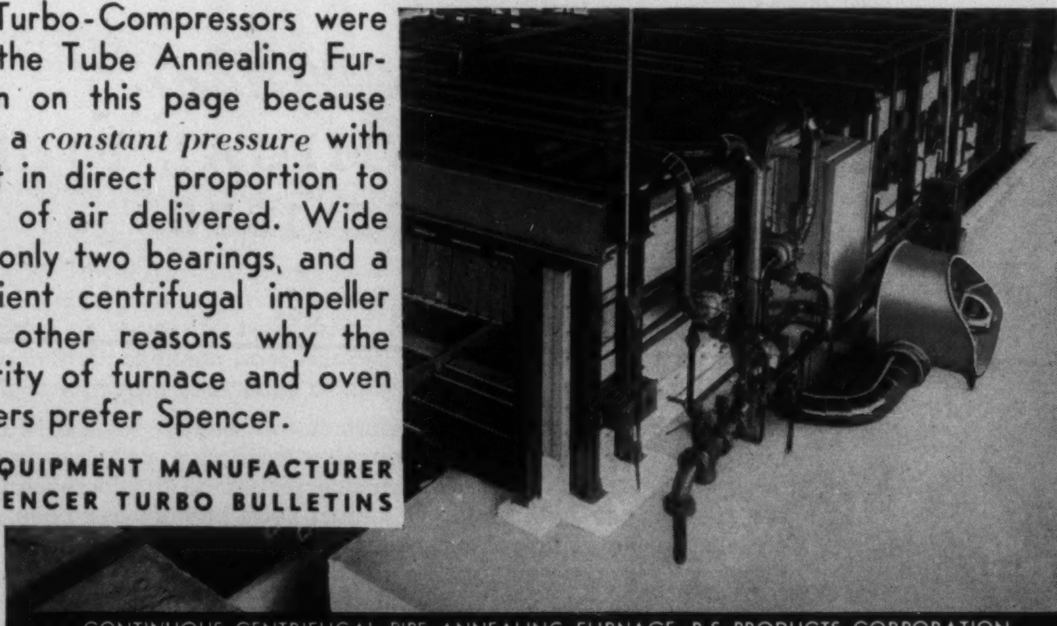

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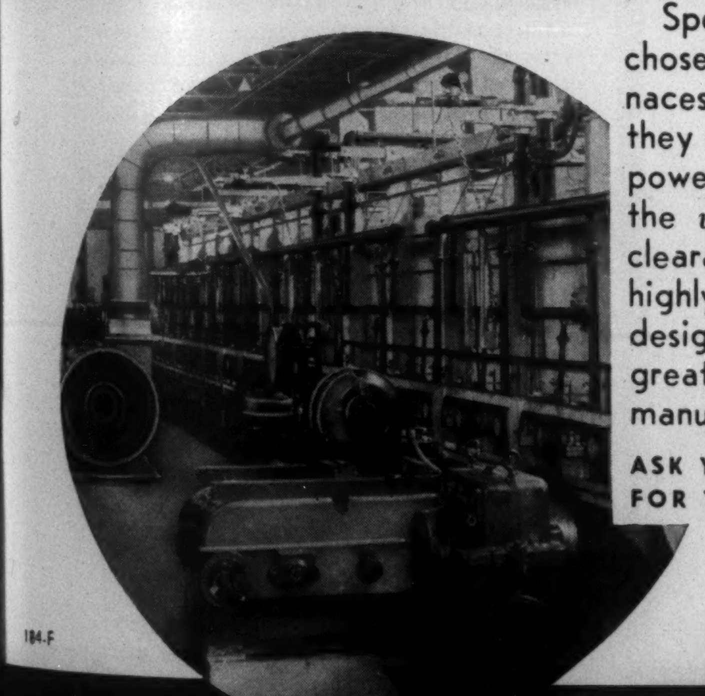

184-F

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stituent metals; compensators" to replace losses; purifiers such as deoxidizers; protectors such as calcium and zirconium for magnesium to avoid changes during melting and casting; and grain refiners. The method and order of addition depend on the nature and state of the materials, as well as on the relative amounts, densities, fusibility, volatility, oxidizability, rate of gas absorption, heat of solution or combination and rate of mutual solution.

The two most simple cases for melting without a special atmosphere and with or without a slag are: (1) Remelting ingots of the desired composition, and (2) melting a charge consisting of metals and alloys with similar melting and superheating temperatures.

In the preparation of master alloys for the latter case, the following factors must be considered: The melting point and superheating temperature, which should be near those of the base alloy; chemical homogeneity, as is often obtained by the use of eutectic alloys; sufficient content of the alloying element to avoid use of a large quantity of the master alloy; adequate chemical stability; if possible, a simple ratio of constituents to facilitate calculation of the charge; and possibility of fragmentation to allow the addition of the correct amount to the charge. The usual order of charging is base metal or alloy, master alloy, and, just before casting, volatile elements and final additions.

JZB (1)

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Top-Charge Arc Furnaces

"Top-Charge Rapid Type Furnaces in the Manufacture of Plain Carbon Steels". H. H. Watson (Pittsburgh 'Lectromelt Furnace Corp.) *Canadian Metals & Met. Inds.*, Vol. 2, Dec. 1939, pp. 308-310.

The increased use of the electric arc furnace for making plain carbon steel ingots to be rolled into merchant and reinforcing bars, sheets and similar products is ascribed to the economic appeal of the top-charge type of furnace. As compared with the older door-charge type, the top-charge furnace can show substantial savings in power, electrode and refractory costs, and labor.

A typical heat in a top charge basic furnace of 5-6 tons operating capacity requires about 100 min. Scrap is charged with about 5% lime and sufficient mill scale. On a 5-ton billet-size ingot heat, in a hot furnace, about 2,000 kw.-hr. will be required to melt down the charge, and an additional 500 kw.-hr. to bring the metal up to tapping temperature, about 2850° F. A thermal efficiency of around 80% obtains during the melt-down period.

In the 'Lectromelt top-charge furnace the roof and superstructure, including electrodes and their accessories, may be quickly raised by an hydraulically-operated ram and swung around 90° to one side, so as to open up the entire body and hearth of the furnace, for quick charging by means of a drop-bottom-charging bucket. This bucket is loaded in the scrap yard and is ready to be quickly lowered into the furnace bowl as soon as the roof is swung aside. The furnace is so equipped that melting power cannot be applied until the roof is locked in its normal operating position.

A furnace of the older door-charge design, operating on 5-ton charges, required a ½-hr. to 1-hr. period from "power off" to "power on" between heats for charging, patching, etc. Use of the top-charge furnace has in some instances permitted cutting this period to less than 5 min.

Comparable operating figures on the two types of equipment in the same mill indicate that early fears as to poor economy for the top-charge owing to excessive heat loss during swing-aside and short refractory life were unfounded. The Table gives comparative operating costs per ton of billet-size ingots made in the two types of 5-ton furnaces, taken from actual operating data. The door-charge figures are the averages for two types of such furnaces. Scrap cost was assumed to be $10.00 per ton of ingot, and power cost 0.6 per kw.-hr.

	Door charge	Top charge
Wages and salaries	3.15	2.00
Materials charged	11.28	11.28
Power and electrodes	4.85	4.15
Refractories and molds ..	1.26	1.15
Miscellaneous	1.12	1.12
	$21.66	$19.70

With respect to refractory cost, operating a top-charge furnace alongside a fixed-roof furnace of the same shell diameter under identical operating conditions, by the same crew, showed, that the average 3-yr. cost of refractories for the fixed-roof furnace was actually greater by 30% than for the top-charge furnace. Electrode consumption was 14% lower for the top-charge.

To date, most of the small ingots have been made in cast iron molds, but it now seems that copper molds may come into wide use for certain kinds of work. The top-charge furnace may of course be used to melt up both old iron or old copper molds for casting new molds when needed. Iron mold maintenance for billet-size ingots has to date averaged 40 cents/ton of ingot made.

The use of the top-charge furnace for tool steels, alloy steels, steel castings, cast iron, malleable iron, nickel, Monel, copper, etc., is well-known. Economies available are admittedly not so great as in the rapid-type of operation described above, but are still favorable. (1a)

Cold Drawing Wire Rods

"A Correlation of the Factors and Effects of Cold Drawing of Wire Rods." S. A. Braley (Pittsburgh Steel Co.) *Wire & Wire Products*, Vol. 15, Jan. 1940, pp. 17-29, 77. Comprehensive review.

The many variables in modern wire production—the type of steel, alloying elements, chemical composition, heat treatment, rolling methods and drawing equipment—have a complicated effect on the properties of the final product. A correlation between chemical analysis alone and tensile strength of steel wire is given by Campbell's formula: 37,430 + 95,000 x C + 8500 x Mn + 105,000 x P + R, where C, Mn and P are the percentages of the corresponding elements.

Thus, a steel of 0.10% C, 0.40 Mn and 0.015 P would give:

37,430
0.10 x 95,000 = 9,500
0.40 x 8,500 = 3,400
0.015 x 105,000 = 1,575

calculated tensile strength = 51,905 lbs./in.^{2}

R is used as a correction for other elements, especially copper and silicon (provided that not more than 0.25% copper is present), and is equal to 25 for each. Low-carbon material will check very closely with this formula, while high-carbon material will show higher values.

The change in tensile strength of steel wire for each per cent elongation is given by Bonzel for mild rimmed steel as 480 lb./in.^{2}; for mild steel killed with silicon as 620 lb./in.^{2}; and for high-carbon steel as 700 lb./in.^{2} However, these relations can be more accurately and efficiently used if expressed as a curve. Such curves are given for a number of materials and show considerable differences from the calculated values. The practical application of these principles permits determination of the maximum anticipated variation in tensile strength in a normal grade of steel for a given composition and drawing practice.

For steel wire used in electrical work, the electrical conductivity can be calculated from R = BT x K/1000 A, in which R is the resistance in ohms, BT the calculated basic tensile strength, A the cross sectional area of wire in in., and K an empirical constant which has been determined to be 0.00603. This formula gives particularly close figures for basic Bessemer and duplexed electric-basic Bessemer wires. Heat treatment, of course, changes the properties, but in a perfectly orderly manner. The formulas are especially useful in setting specifications.

Ha (1a)

Desulphurizing Pig Iron with Calcium Carbide

"Desulphurization of Pig Iron with Calcium Carbide." C. E. Wood, E. P. Barrett & W. F. Holbrook (U. S. Bur. Mines) *Metals Tech.*, Vol. 6, Dec. 1939, 15 pp. Research.

Both laboratory and plant studies indicate that calcium carbide is an active desulphurizer when intimately mixed with molten pig iron. Several devices are shown for introducing calcium carbide into molten iron in such a manner that the desired removal of sulphur will result. For producing very low-sulphur (below 0.02%) metal, calcium carbide seems to offer some advantage over alkalies, principally because the efficiencies of alkalies decrease greatly as low-sulphur contents are approached. Calcium carbide does not harm refractories as do alkalies.

Thus, the extent to which calcium carbide may be used as an auxiliary desulphurizer will depend on the ultimate cost of the treatment of large amounts of metal and on the actual demand for metal containing less than 0.02% sulphur. Metal containing 0.01% or less of sulphur can be produced at a cost that does not appear to be excessive for this type of metal. Part of the cost of carbide treatment can sometimes be offset by operating the blast furnace on a more acid slag. This would result in a lowering of the coke consumption, an increase in pig iron production, and a smoother operating furnace. JLG (1a)

Steel Sheet Defects

"Steel Sheet Defects." T. Grey-Davies. *Sheet Metal Ind.*, Vol. 13, Dec. 1939, pp. 1429-1430. Practical.

A "running" or "dribbling" stopper during teeming leads to the formation of scabs because the splashes of steel on the walls of the ingot mold chill and oxidize before the mold is filled. Such seams and scabs may not be detected until after the final cold rolling. Running stoppers can be avoided by proper choice of design and material for stoppers and nozzles. Most nozzles are of fireclay which is cheap but rapidly eroded and corroded during pour-

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ing. Special magnesite nozzles with a higher resistance to erosion are sometimes used for very erosive steels such as rimming steel; however, the thermal conductivity of the magnesite is so high that the metal tends to freeze in the nozzle. Composite nozzles have some advantages. The stopper end is generally more refractory than the seating; in this way the seating is slightly plastic in service and gives a better seal.

Ladle life has been considerably increased by the use of special ramming mixtures and careful drying and preheating. The nozzle wear is somewhat offset by the difference in flow rate due to decreasing ferro-static pressure of the metal in the ladle. An example is given of the variation in rate of flow with decreasing height of metal in the ladle. These figures are valid only for the type of steel involved in the test, as chemical composition and temperature greatly affect viscosity of the steel. Usually the more highly deoxidized a steel is, the greater is its viscosity. JZB (1a)

Steel Castings for Aircraft

"Steel Castings in Aircraft." Alexander Finlayson. *Iron & Steel*, Vol. 13, Oct. 1939, pp. 11-13, 16. Practical.

Steel castings for transports and military planes include landing gear and knuckle weighing 128 lbs. and 92 lbs., respectively, as-cast, finishing to 81 lbs. and 60 lbs., with even then a saving in cost over originally forged parts. A steel of the chromium-manganese-molybdenum type (0.40% C, 1.35 Mn, 0.90 Cr and 0.30 Mo) was tried but Magnaflux testing revealed many small cracks, especially at fillets. These cracks were ground out but often reappeared after heat treatment. A nickel-bearing steel (0.40% C, 0.70 Mn, 0.90 Cr, 1.40 Ni and 0.30 Mo) was tried but gave no better results; hot tears and cold cracks recurred and heat checks and quenching cracks resulted from welding.

A copper-silicon alloy steel was developed (U. S. Patent 2,034,136) containing 0.12-0.20% C, 1.10-1.35 Mn, 1.0-1.25 Si, 1.5-2.0 Cu and less than .045 each S and P, and this proved successful. It gave good fluidity and cleaner surfaces since it could be poured at a lower temperature than usual, could be welded in the hardened as well as the annealed condition and withstood quenching. All work was done in dry sand double-washed with zirconium oxide, oven-dried after each application. This practice must be carefully controlled or poor castings will result. All castings are shot-blasted and carefully Magnafluxed in the rough and, if passed, are then machined, pickled, cadmium-plated and given a final Magnafluxing.

The cadmium plate is primarily for corrosion resistance but serves also to reveal the location of slag spots, oxides, spongy areas, and often internal fissures, because the cadmium does not deposit on such flaws. The landing gear knuckles are X-rayed to be sure that no harmful internal cavities and shrinks are present. Finally, a "drop" test simulating a 45,000-lb. plane landing at 80 m.p.h. is performed 4 to 6 times. This involves loading half the landing gear to 22,000 lbs. and letting it fall 25 in.

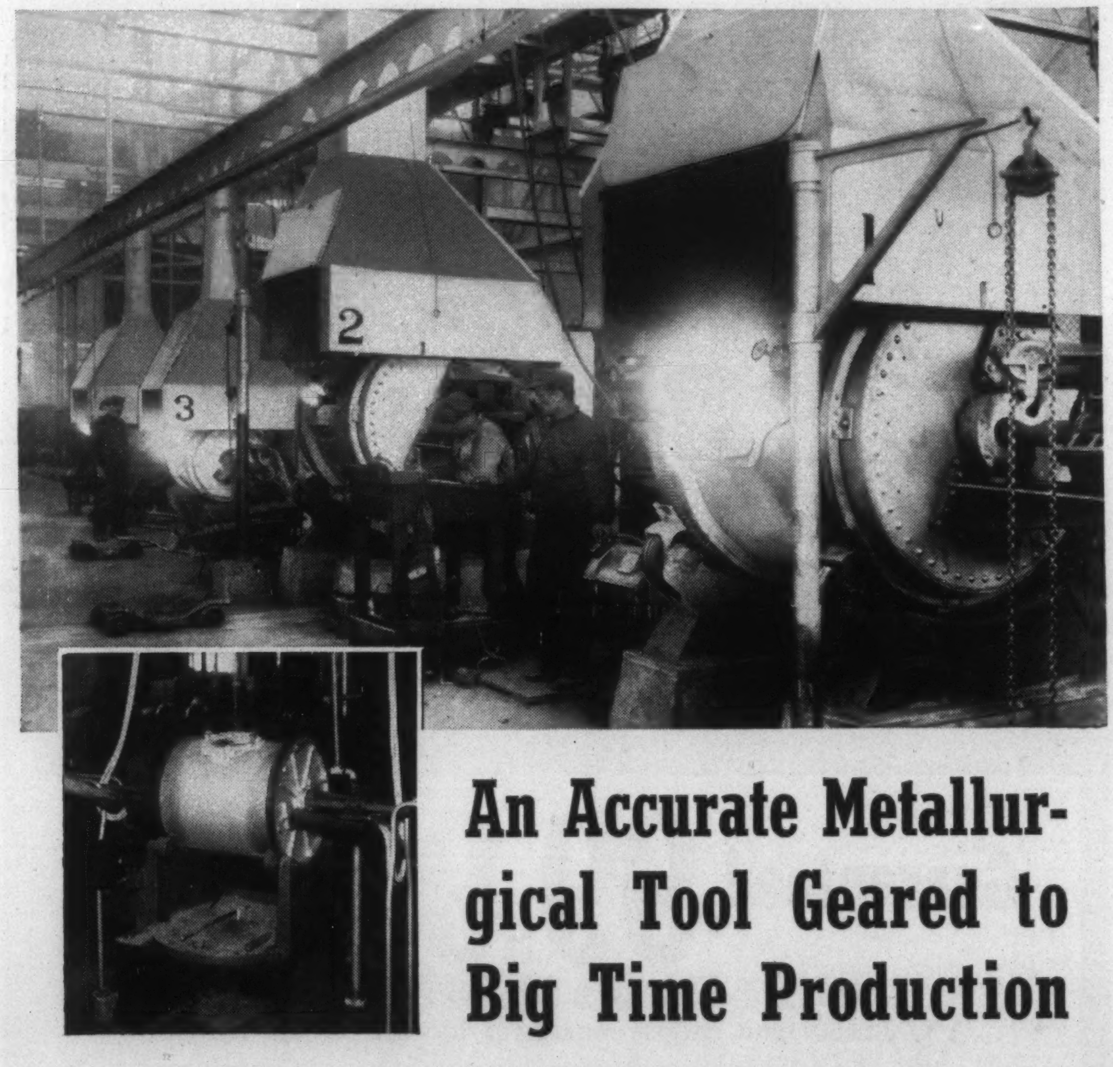
The extent to which Magnaflux-detected cracks prophesy the true service performance of a casting is discussed. Notable is the comment on the pressing need for research on the *steel casting* as differentiated from *cast steel*. ". . . not just an empirical, trial and error, cookbook procedure of testing sand mixtures, bonds and binders, but a comprehensive investigation by men divested of traditional materials and methods, seeking a better way (of founding), perhaps not sand at all." HFT (1a)

Alloy Iron from the Cupola

"Cupola Operation for Making Alloyed Cast Iron." *Foundry Trade J.* Vol. 62, Jan. 4, 1940, p. 8. Practical.

In melting alloy cast iron in the cupola, the size of the coke charge should be determined first and the weight of the metal charge adjusted to suit. The ideal thickness of the layer of melting coke between each charge should be 6 to 8 in., and the weight of the metal charge should vary between 8 and 12 times the weight of the coke layer. For good quality gray iron mixtures consisting entirely of pig iron and scrap, it is best to begin with a ratio of 10 parts of iron to 1 part of coke by weight. When much steel scrap is incorporated in the mixture, it is advisable to reduce the weight of metal in each charge and keep the weight of melting coke constant. A high coke bed is essential if hot metal is to be obtained right from the first tap.

For base irons to which nickel or nickel plus chromium additions are to be made, high initial temperatures give smoother working, easier handling of the molten metal, and better castability. After the stack is completely charged up to the charging door, a soaking period of at least 1 hr. should be allowed. When there is no steel in the charge, pig iron and scrap may be charged one on top of the other or mixed together. Very large lumps should



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be avoided. Where alloys such as "F" nickel ingot, ferrochromium, ferromanganese or ferrosilicon are constituents of the mixture, these should be placed in the center of each charge, and care should be taken to keep them as far as possible in the center axis and away from the cupola wall.

When 20% or more steel scrap is charged, the following order of charging has been found to give good results: (1) Pig iron on coke; (2) foundry returns or remelt and scrap; (3) nickel and ferroalloys; and (4) steel scrap. If the pig iron or foundry returns melt and accumulate first, the resulting metal contains sufficient silicon and manganese to ensure deoxidation of the remainder of the charge as it melts. Also, when steel comes down last, it remains in contact with hot coke a shorter period of time than if otherwise melted, and less carbon is absorbed. Where alloy cast iron or base metal for alloy ladle additions must form the first part of the melt, it is essential to preheat the ladle thoroughly. When steel-mix cast iron of low total carbon content is being produced, the metal should not be left in the well for too long a period. AIK (1a)

1b. Non-Ferrous

Roll-polished "Nickel Silver"

"ROLL-POLISHED NICKEL SILVER." T. D. FEARNEHOUGH. *Metal Ind., London,* Vol. 55, Dec. 29, 1939, pp. 543-544. Practical.

The manufacture of polished "nickel silver" sheet is on the increase. The compositions commonly used for polished sheet are 60% Cu, 10 Ni and 30 Zn; 62% Cu, 15 Ni and 23 Zn; 62% Cu, 18 Ni and 20 Zn. All of these can be made by direct crucible melting into a convenient-sized 90-lb. ingot. After casting, the ingots are surfaced with a planing machine, then rolled in the usual manner.

To produce a 0.02-in. sheet, the special procedure starts when the ingot has been reduced to a 0.05-in. sheet. After annealing the sheet is pickled in a dichromate-sulphuric acid bath to produce a clean white surface. The visible surface defects are removed and rolling is continued. When the sheet has reached .023 in., it is annealed and pickled as before, then given a bright dip in a nitric-sulphuric acid solution and sent directly to the polishing rolls. These rolls have a fair polish and the operation is carried out in a dustless room. The sheet is swilled with paraffin and about 30 passes are required to produce the proper polish.

Too high a polish on the rolls is ineffective in increasing the polish on the work; the correct polish on the rolls is best judged by experience. Dust, lint, oil, fingerprints, etc., all cause defects in the finished surface. Muffle annealing during processing is preferable to bright annealing, as the oxide formed tends to remove surface defects. RWB (1b)

Making Aluminum Cable Sheaths

MANUFACTURE OF ALUMINUM CABLE SHEATHS ("Herstellung von Aluminiumkabelmanteln") WALTER DEISINGER. *Z. Metallkunde,* Vol. 31, Sept. 1939, pp. 305-310. Review plus original research.

Since 1927 efforts have been underway in Germany to employ aluminum instead of lead for cable sheaths, as the heavy weight of lead sheath, its low mechanical strength, and frequent fatigue failures are serious shortcomings. Early attempts to use welded sheaths of pure aluminum yielded unsatisfactory results, mainly because of the effect of the high welding temperature on the cable. The possibilities of extruding aluminum cable sheaths have been explored since aluminum of 99.99% purity became available commercially.

A diagram shows the specific extrusion pressure, in relation to temperature, of lead, lead containing 0.8% Sb, 99.5% pure aluminum and 99.99% pure aluminum. The necessary pressures for extruding "purest" and pure aluminum are respectively 2.5-3 times and 4 times as high as with lead. Experiments in a small press are fully described. The forces necessary to overcome the internal friction of aluminum are considerably larger than with the formerly-employed cable material, with reference, of course, to homologous temperatures. Further studies were made of the success of pressure welding as dependent on the surface condition of the aluminum, the temperature and the pressure. Purest aluminum furnished an excellent joint (as proved by photomicrographs) even when the surface was purposely oxidized.

The difficulties encountered in translating these laboratory tests into the 3 processes commercially employed for lead cable sheath extrusion are discussed at length. The typical defects of extruded aluminum sheaths are illustrated. It is concluded that with specially constructed presses and better construction materials, the commercial manufacture of aluminum cable sheaths will be possible in the not too distant future. EF (1b)

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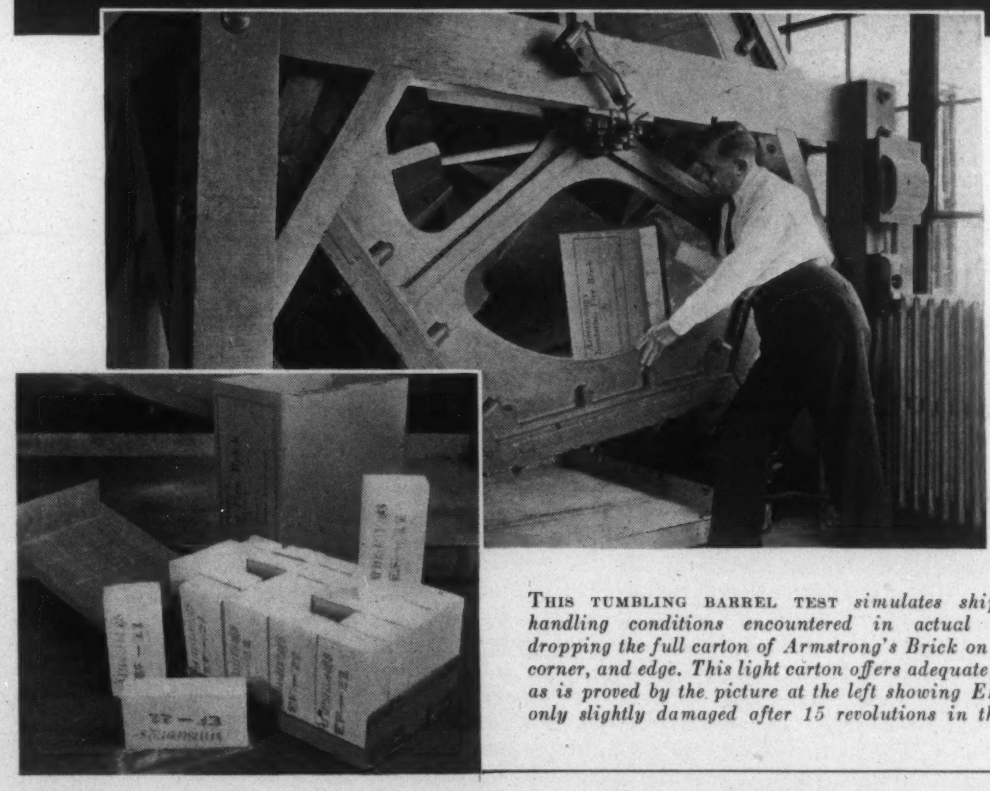

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2a. Ferrous

Tools for Pressing and Drawing

A Composite

Tools for pressing and drawing metals are of many-sided interest to metallurgical engineers. Such tools are practically always metals—with all the structural, surface and mechanical problems common to metals—and at the same time are employed for fabricating other metals into industrial products. The selection and heat treatment of tools for deep-drawing and pressing various metals, tools for shaping light metals, and factors affecting the behavior of press tools under fatigue and impact are discussed in several recent articles.

Tool materials — from wood through high speed steel—and their heat treatment are discussed in a series of articles by J. D. JEVONS ("Tools for Deep Drawing and Pressing," *Metal Ind., London*, Vol. 55, Oct. 20, 1939, pp. 355-357; Nov. 17, 1939, pp. 425-428; Nov. 24, 1939, pp. 449-451; Dec. 8, 1939, pp. 485-486). Wood possesses several useful and unique properties as a tool material, as it is the cheapest, lightest and most easily shaped tool material, and is incapable of fouling or loading. Because of its softness, however, it can be used to produce only a relatively small number of pieces from thin, soft sheet. Rubber is another non-metallic tool material that is often used.

The use of soft metals for tools is more common than is usually supposed. They occupy an important if small area in the large field of tool materials. According to W. W. BROUGHTON of Morris P. Kirk & Sons ("Zinc-Alloy Dies for Drop Hammer Work," *Iron Age*, Vol. 145, Feb. 8, 1940, pp. 29-32), zinc-base alloys of the type used for die castings are preferable to combination lead-zinc or straight zinc for aircraft stamping dies, and their use for this purpose is increasing. Dies made from one such zinc alloy (A.S.T.M. alloy XXI modified to give better sand cast properties) are producing 10-50 times as many stampings as did their predecessors made from straight zinc.

According to Jevons, the selection of the tool material is definitely the province of the "metallurgist" rather than the tool designer or draftsman [unless, of course, the latter are also specially trained in metallurgical engineering]. In small tools the cost of material does not entirely preclude the use of expensive alloy steels. Cast iron is of special merit for the deep drawing of steel, and is by far the cheapest; nitrided alloy steel is the most expensive tool material. Cast-to-shape tools, from the cost standpoint, have a great advantage over machined-from-block tools.

One of the great reasons a metallurgical engineer of some kind should be a factor in tool material selection and tool design is the frequent laxity of many tool designers and toolmakers with respect to the avoidance of notches, scratches, machine tool marks and sharp corners. C. E. BRETNEY ("Failure of Press Tools under Fatigue and Impact," *Metal Progress*, Vol. 36, Dec. 1939, pp. 751-754) discusses the effect on fatigue strength of tools so marred, and on parts made from the tools. Fatigue strengths of polished specimens may be reduced 2 to 50% by grooves, tool marks, etc. from 0.001 to 0.003 in. deep. High impact values are also essential for most tool applications and a frequently useful index of merit is the ratio of impact value to hardness.

A change of steel, in the event of tool failure, will not necessarily eliminate the trouble, particularly where there is an especially dominant stress concentration. On the other hand, the simplest remedy—to eliminate the stress concentration—isn't always possible, and several cases are on record where a change of steel entirely cured a serious difficulty although the recognized stress concentration remained. Often the substitution of high speed steel for plain carbon or high carbon, high chromium tool steel will increase tool life from 3 times to many hundred times the original number of operations.

However, wholesale substitution of high speed steel in blanking dies is not advisable, especially if the metal being blanked is very thin. Jevons explains how careful design will sometimes permit the safe use of a tool material more suitable from the general service aspect than one that must perforce be used if "stress raisers" be present. In describing tools for drawing aluminum, L. J. WEBER & J. T. WEINZIERL of Aluminum Cooking Utensil Co. ("Drawing of Aluminum," *Trans. Am. Soc. Metals*, Vol. 27, Dec. 1939, pp. 1052-1071) find the "high grade alloy tool steels" best for draw tools when the quantity of shells to be produced is sufficient to justify the cost, but like Jevons, prefer cast iron or alloy cast iron for most jobs where a few scratches from the tools won't matter but too much operating expense will.

Another viewpoint is that of F. RAPATZ & J. FREHSER ("Werkzeuge für die Formgebung von Leichtmetall-Legierungen," *Aluminium*, Vol. 21, Nov. 1939, pp. 747-754), who favor the use of low-alloy tool steels containing various combinations of carbon, chromium, tungsten, vanadium and molybdenum (total alloy content less than 8%) for shaping light metals. Weber & Weinzierl also put in a good word for the plain carbon steels with 0.60-1.10% carbon, which can be hardened by oil or water quenching from the upper critical and tempered to obtain the desired hardness.

The importance of the heat treating stage in the production of tools and dies for press operation is stressed by Jevons. Tool steels should always be thoroughly normalized prior to hardening. Cast iron tools should not be "normalized" in the true meaning of the term. A maximum temperature of 1200° F., and this but for a short time, should be used to relieve stress without changing the microstructure. Too rapid heating causes both cracking and distortion. Above 1200° F. the heating rate can be increased without risk. The soaking time prior to quenching is important, and varies with different types of cast iron and steel. Prolonged practical experience seems to be the only safe guide to the choice of soaking time for any given material and section.

The most important factor is quenching. Steels of almost identical chemical composition, from different manufacturers, react differently when quenched under identical conditions. In quenching, adequate tank size and submerged jets to impinge on the important tool faces are recommended. Soft spots, defects commonly attributed to quenching procedure, may be caused by material adhering to the tool or by use of water which has not recently been boiled. Brine is preferable to water for a still bath. Tools should pass immediately from quenching to tempering. The practice of delayed tempering even for a few hours may result in cracking that could have been prevented by immediate tempering.

Every precaution should be taken to prevent decarburization of the working faces of tools. When size permits, tools are packed in a non-active medium such as iron swarf or charcoal to prevent decarburization. Iron swarf should be clean or local carburization may occur. Charcoal should be of wood and sieved to remove small particles and dust; the use of spent carburizing compound should be avoided. Iron swarf is preferred at low temperatures and charcoal at high. For large tools, controlled atmosphere furnaces are preferred. Care in their use is necessary. Really clean surfaces from controlled atmosphere furnaces should be viewed with suspicion, as

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they quite often may indicate a reducing atmosphere; a dull surface, with a very thin coat of scale, is far safer practice. "Clean hardening" furnaces are safer than "bright hardening" furnaces.

Bretney gives considerable attention to the effect of tempering temperatures on the impact values of plain carbon and alloy tool steels, and shows that it may be poor practice to temper plain carbon tool steels at low temperatures (300° F.) to obtain maximum impact value and thereby sacrifice other valuable qualities, such as bending strength. On the other hand, a high speed steel tempered at 700° F. would have too low an impact value to be of practical merit, though tempering at 500° F. or 850° F. to give higher impact in both cases with a higher or lower hardness, respectively, might be advantageous. In all such cases, the application of the tool decides what tempering temperature should be used. X (2a)

Heat Treating Magnetic Alloys

A Composite

The attainment of the properties required of magnetically soft materials is often directly dependent on their heat treatment. This is especially true of the precipitation hardening iron-nickel-copper alloys, which have moderately high but approximately constant permeabilities over broad ranges of flux density. Two recent German articles report studies on the effect of age-hardening on magnetic properties of such alloys, and on their recrystallization structures.

During the precipitation of carbon and nitrogen (however combined) from α-iron, the coercive force rises, passes a maximum, and drops again. The permeability takes the opposite course, a minimum permeability value usually corresponding to the maximum coercive force. The high-permeability iron-nickel-copper alloys act differently—upon suitable heat treatment an abnormal rise in permeability occurs before the coervice force changes. Such abnormal magnetic behavior during age-hardening is investigated by H. BUMM ("Magnetisch anormale Eigenschaften bei aushärtbaren Legierungen," *Z. Elektrochem.*, Vol. 45, Sept. 1939, pp. 671-674), using 2 alloys analyzing (a) 51.5% Fe, 35.5 Ni and 13 Cu; and (b) 50.5% Fe, 34.5 Ni and 15 Cu.

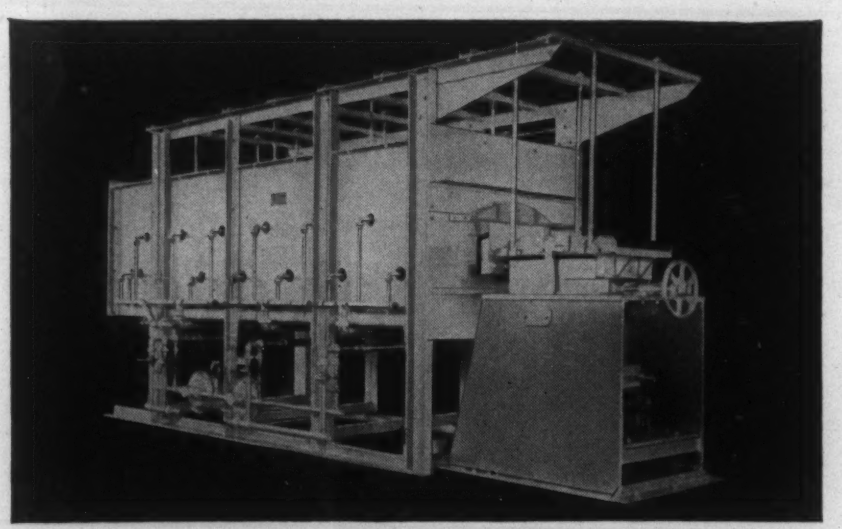
After homogenizing at 1000° C., cooling in hydrogen, and aging at 500° C., an abnormal increase in electrical resistivity was observed, as is found in many age-hardening alloys. With higher annealing temperatures the resistance drops gradually with copper precipitation. The initial permeability rises (with the same heat treatment), reaches a maximum value and then drops away below the initial value in the as-quenched condition. The increase in permeability is 30 to 40%.

Alloys with high initial permeability and low rate of increase of permeability with H are very desirable in the industry. The homogenizing temperature was found to have a profound influence. Alloy (a), homogenized at 1000° C. and aged at 600° C. for 5 hrs., has a maximum permeability of 2200, with 45% proportionate increase. The "proportionate increase" is arbitrarily defined as the percent increase in permeability when H increases from zero to 0.1 oersteds. After homogenizing at 850° C. and aging at 600° C. for 5 hrs., the permeability reaches a maximum of 2600, with an increase of only 11%. Alloy (b) homogenized at 1000° C., air cooled, and aged at 600° C. shows some increase in initial permeability, but it drops rapidly after prolonged aging. The amount of increase is about 50%. After homogenizing at only 900° C. and aging at 600° C. for 3 hrs., a maximum permeability of 4100 is reached, with an increase of only 22%. If after homogenizing the alloys are quenched in water instead of air there is no increase in permeability during aging; the rate of change, however, depends mainly on the homogenizing temperature.

The abnormal increase in permeability is explained as due to the beginning of dispersed precipitation of copper atoms; this is the actual precipitation by which the lattice constant of the base lattice is changed, whereas the precipitated phase appears in finest distribution so that it cannot be detected by X-rays or microscope. The influence of the homogenizing temperature is explained by stresses set up by small amounts of copper precipitated or not completely dissolved during the anneal near the heterogenizing limit. Owing to the low diffusion and precipitation rate of copper the aging process can be followed and controlled conveniently so that any desired combination of initial permeability and percentage increase may be obtained.

The type of structure obtained after recrystallizing such alloys is also of great commercial importance, according to H. G. MUELLER ("Rekristallisationstexturen der Flächenzentrierten Eisen-Nickel-Kupfer Legierungen," *Z. Metallkunde*, Vol. 31, Oct. 1939, pp. 322-325), who studied the recrystallization textures of face-centered iron-nickel-copper alloys—binary as well as ternary combinations—by X-rays.

The ternary alloys recrystallize between 500° and 550° C. as long as they form solid solutions. Precipitation-hardening alloys recrystallize at temperatures which increase with increasing degree of heterogeneity, except at extreme temperatures (over



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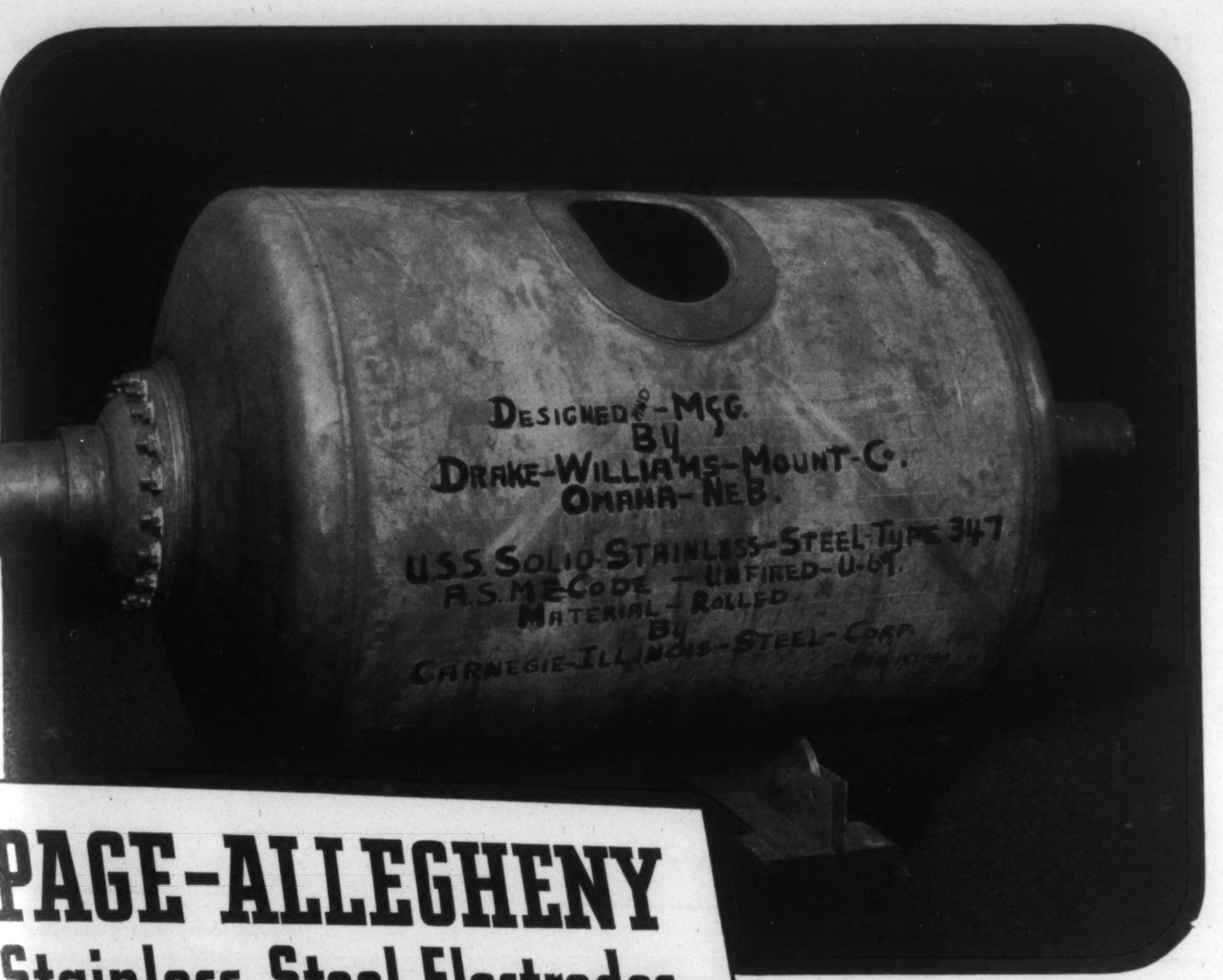
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900° C.). The phase-boundary lines and the recrystallization isotherms take the same course in the ternary diagram.

A certain concentration range was characterized by a phenomenon not hitherto observed; *viz*, alloys in this range showed, 300° C. below the normal recrystallization temperature, a second "abnormal" one. At the latter temperature (about 600° C.) the mobility of the atoms is relatively small and the heterogeneous components become surrounded by the recrystallizing grains. At temperatures (700°-900° C.) just below the normal recrystallization temperatures foreign atoms collect immediately at the outside of the recrystallization nuclei and prevent grain growth. Owing to the increased solubility at still higher temperatures, unrestricted recrystallization takes place as the temperature becomes higher than 900° C.

Regarding the kind of recrystallization texture, the latter was found to be random in samples annealed close to the recrystallization temperature. If the alloys are subject to precipitation at the annealing temperature, the recrystallization texture was the same as the rolling texture. A ternary diagram shows which alloys furnish the very important "cubic position" (*Wurfellage*) at very high temperatures. If the annealing time is too long, this texture is destroyed by grain growth. A narrow composition range exists in which either the "rolling texture" or the "cubic texture" may be obtained, depending on the annealing temperature.

X (2a)

Stack-Cutting Identical Parts

"Stack-Cutting of Identical Parts." *Can. Metals Met. Inds.*. Vol. 2. Nov. 1939. pp. 282-284. Descriptive.

The production of large numbers of identical parts from thin steel plate by oxyacetylene cutting machines is greatly expedited by the use of stack-cutting methods, in which the plates are piled, clamped tightly together, and cut as if one solid piece of metal. Stack-cutting has made practicable the oxyacetylene cutting of thin sheets and has resulted in an increase in the production capacity of the oxyacetylene cutting machine, greater uniformity of the shape-cut parts, and a lowered unit cost of production.

Under proper operating conditions, the cut edges on all the stacked plates are left smooth, so that further machining is reduced to a minimum and is frequently eliminated entirely, especially if the edges of the sheets are subsequently to be welded.

The selection of the depth of the stack depends to some extent on the quality and accuracy of the cut desired. Stacks not more than 2 in. deep can be cut with an edge tolerance of 1/32 in.; where extreme tolerances are not required, it is more economical to use stacks from 3 to 4 in. thick. Over 4 in. the accuracy diminishes. A small stack is generally used for cutting light-gage metal so as to prevent melting the top sheet edge with the large preheating flame that would be necessary for a thick stack, and also to prevent fusing of the sheets together by the greater heat.

One company is successfully cutting 24 sheets of 16-gage material by clamping the stack with wedge-type clamps and using a ¼-in. pressure member piece along the line of the cut. C-clamps, toggle clamps, powerful electromagnets and the application of welded beads are also widely used for holding the stacked sheets together.

For heavy production work, one shop has installed a cutting machine able to accommodate the progressive cutting of 4 different parts of large dimensions. Permanent full-size templets have been constructed which can be slipped into position almost instantly on the top of the cutting machine table by the guiding action of permanently located jigs and stops. Stack-cutting has also been applied with great success in the production of circles of various sizes in plates varying from 1/16 in. to ½ in. in thickness.

Stack-cutting of small intricate shapes is readily accomplished by means of a cutting machine which can be made to follow a templet design automatically. A typical application of this type is the shape-cutting of linoleum-cutting knives six at a time, from 9/16 in. boiler plate. Actual cutting time per stack varies from 9 min. to 12 min., which includes the making of two starts, one for the octagon-shaped holes in the center of the knife and the other for the outside profile.

The edges of the oxyacetylene cut sheets are square and full with no burrs or slivers. A particularly advantageous feature of stack-cutting is the saving effected from the recovery of usable material. With the oxyacetylene cutting process the metal removed is in large pieces that can frequently be used in the manufacture of other parts. Frequently, by proper designing, the scrap can be used without further fabrication.

WHB (2a)

Strain Annealing Cold Drawn Bars

"Strain Annealing". Frederick J. Robbins (Bliss & Laughlin, Inc.) *Iron Age*, Vol 144, Dec. 14, 1939, pp. 33-38; Dec. 21, 1939, pp. 37-39. Practical.

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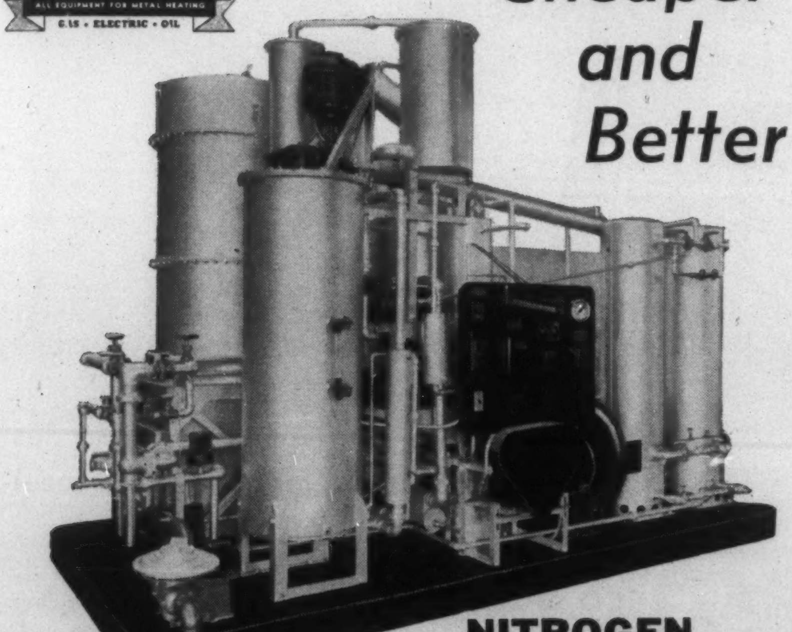

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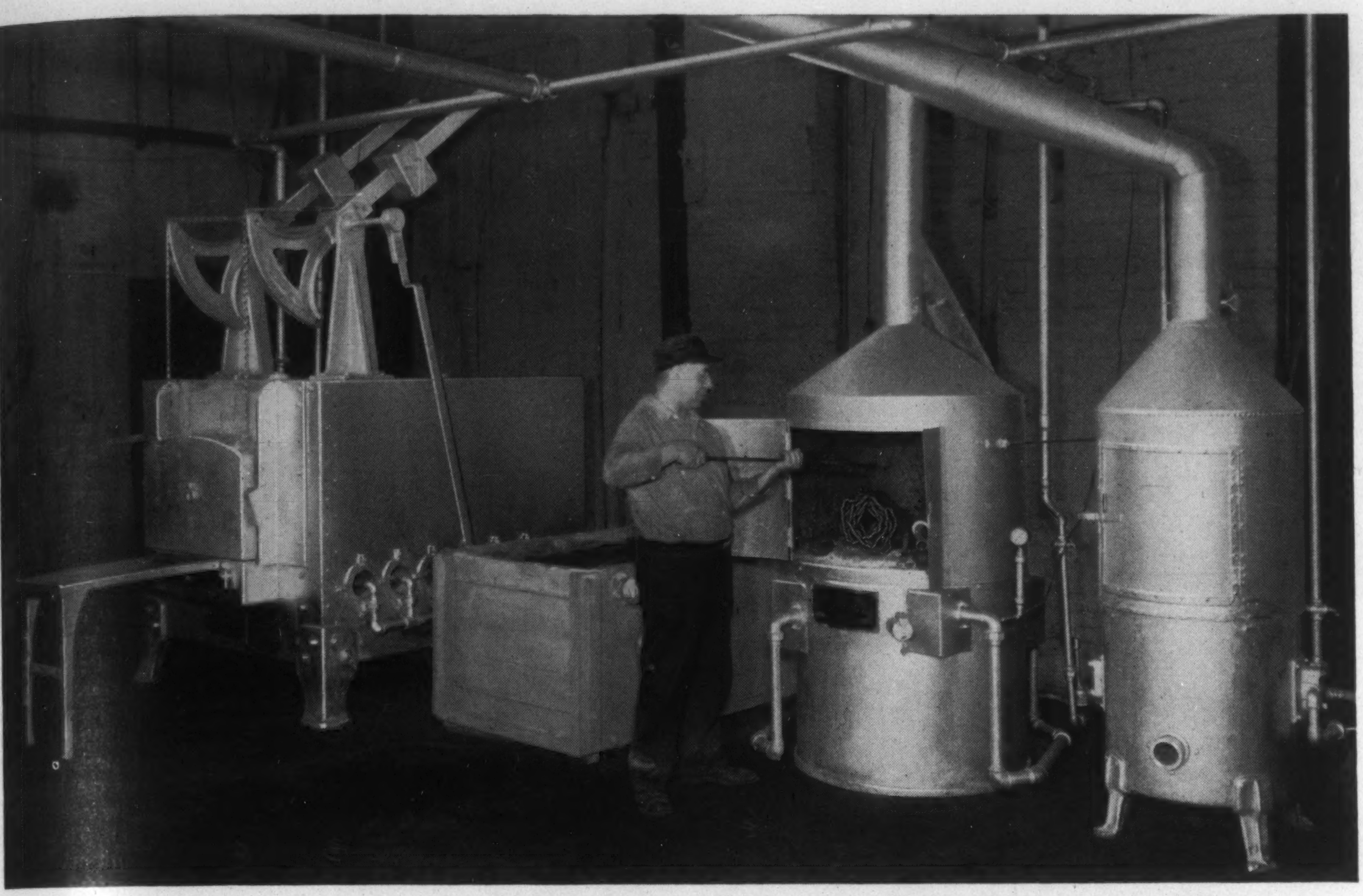

Gas-fired equipment in a heat-treating shop in the plant of The Free Sewing Machine Company, Rockford, Ill.
Photo courtesy Eclipse Fuel Engineering Company, Rockford.

More work in less time for Sewing Machine Plant with GAS heat treating

Heat treating with Gas plays a very important role in the manufacture of sewing machines, as witnessed by the experience of The Free Sewing Machine Company of Rockford, Ill.

Four years ago—with old-type equipment—it "took a full day to bring the oven furnace up to temperature and an even heat throughout the chamber was practically impossible." As a result, on carburizing work the plant could place in the furnace only one layer of boxes. With this equipment, it could get two carburizing heats per day, and by allowing the furnace to run through the night, it could get one annealing heat.

Since installing the new Gas equipment, it is possible to get two carburizing heats and one annealing in an eight-hour day, and to double the loadings in each charge. With no annealing to do, the plant can run through *three* carburizing heats.

Working space has been increased by the new installation. And with this Gas-fired equipment it is now possible to control temperatures more accurately. Working conditions are better, too, since the heat loss is less; and the plant can also be kept very clean, says Mr. R. E. Johnson, an official of the company.

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of cold drawn bar characteristics, strength, and ductility holds some excellent possibilities. The applications of strain annealing treatments of cold drawn bars fall into the following classifications: (1) Complete relief of all cold working strain; (2) relief of cold work strain to a limited degree, for increasing the ductility of material; and (3) relief of strain in heavily cold worked steel to obtain tensile properties somewhere between cold-drawn and heat-treated properties.

Cold drawing is done on all analyses of steels and results in setting up internal strain. High-carbon steels, because of their higher hot-rolled hardness, produce a higher cold-drawn hardness than do the lower-carbon steels. The principal difference in processing to produce the flexibility desired for strain-annealed characteristics lies in the amount of cold reduction imposed upon bars in cold drawing them from the hot-rolled state. The effect o different drafts and the amount of strain set up can be measured by the resultant change in hardness. An anneal above the recrystallization temperature is necessary when very large amounts of reduction are to be made. This is not the case in cold drawn bars where the per cent of reduction is low as compared with wire drawing. The Rockwell hardness test provides a suitable method for indirectly measuring the amount of strain. Tests are made on ground transverse section of bar on perpendicular diameters, unless the diameter is too small.

Graphs depicting the varying amounts of drafts on S.A.E. 1020 and X-1315 steels show that the first 1/32 in. draft brings the greatest increase in hardness, and that subsequent increasing drafts result in less increase. The center of the bars at first show a smaller increase in hardness than the bar surface, but as the draft increases this lag is taken up and the effect of cold working is approximately equal throughout the section. The heavy draft has a profound effect upon ductility, particularly where the steel is susceptible to cold working, as in the case of Bessemer screw stock.

Increased brittleness has a beneficial effect in machining. Extra drafting in cold drawing of these types of steels possesses no real industrial advantage. Curves showing the effect of different drafts on S.A.E. X-1335 and 1045 and leaded 1045 steel indicate that no great flexibility can be expected from changes in draft only. The stress-strain curves show the typical cold drawn curve bending away gradually from the straight line, and with no "kneeing" effect. This reveals the presence of considerable strain, so that from the practical standpoint each further increase in stress in service makes failure more imminent. In order to eliminate this strain a low temperature anneal has been resorted to.

The increases in tensile and yield strengths, elongation and reduction of area, and impact strength that occur on release of strain are tabulated. The stress-strain diagrams for the strain-annealed steels, under ordinary cold-drawn stock are straight lines up to a point where a sharp "kneeing" effect occurs. Machinability is the major factor in the use of steels of this type, because fabrication costs can be kept to a minimum. Sometimes strain-annealed steels are subject to distortion. The relief of strain at 950° F. will permit machining without distortion. The real cost advantage in using steel cold drawn followed by strain annealing lies in the elimination of heat treatment as a step in production.

Some applications for which these steels are suitable are lathe lead screws, worms for stoker feed unit, centrifugal pump shafts, certain kinds of collets, jack screws and spindles. From the engineering standpoint it is obvious that this method of manufacturing automatically imposes certain definite limitations in hardness and mechanical properties attainable. VSP (2a)

Hardenability of Alloy Steels

THE HARDENABILITY OF CHROMIUM-MOLYBDENUM AND CHROMIUM-NICKEL CARBURIZING STEELS ("Die Durchhärtung von Chrom-Molybdän- und Chrom-Nickel-Einsatzstählen") A. POMP & A. KRISCH. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch., Düsseldorf*, Vol. 21, No. 21, 1939, pp. 309-326. Original research.

In continuation of earlier investigations (see *Metals and Alloys*, Vol. 9, Dec. 1938, p. MA 731R/8) five alloy carburizing steels were tested to determine the core properties of case-hardened pieces whose diameters ranged from 0.2 to 2.4 in. The steels were (1) aircraft material 1407, with a nominal composition of 0.14-0.20% C, 0.6-0.8 Mn, 0.8-1.1 Cr and 0.2-0.3 Mo; (2) aircraft material 1408 with 0.17-0.23% C, 0.8-1.1 Mn, 1.0-1.3 Cr and 0.2-0.3 Mo; (3) aircraft steel 1409 with 0.16-0.20% C, 0.4-0.6 Mn, 1.8-2.2 Cr, 1.8-2.3 Ni and 0.2-0.3 Mo; (4) steel ECN 35 with 0.1-0.17% C, 0.55-0.95 Cr, and 3.25-3.75 Ni; and (5) steel ECN 45 with 0.10-0.17% C, 0.9-1.3 Cr and 4.25-4.75 Ni.

The aircraft steels were quenched in oil from 1550° F. and tempered 2 hours at 320° F., the other 2 steels were quenched from 1440° F. in oil and tempered 2 hrs. at 265° F. An automatically controlled furnace was used for heating, an electrically

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heated oilbath for tempering. The result of tests of Vickers and Brinell hardness along the surface and across the section, tensile tests, notch-impact tests and fatigue bending tests are given. Surface hardness over the surface was practically the same, although differences can be observed to correspond with changes in carbon content and chemical composition; thus, rods of 0.2-0.4 in. diam. had surface hardness of 298-329 Vickers, of 0.8-1.2 in. 209-229 Brinell. Measurements of hardness across the section showed differences of 30 units in the 0.2-0.4 in. rods, and even 80 in the same grade of steel by another maker. Rods 1.2 in. in diam. had, in general, hardnesses that were 10 units lower than 0.8 in. rods.

The prescribed tensile strength for these steels (128,000-156,000 lbs./in.^{2}) was reached only in the 0.2 and 0.4 in. rods while the 0.8 and 1.2 in. rods showed values as low as 97,000-120,000 lbs./in.^{2} The ratio of elastic limit to ultimate strength, supposed to be 75%, was not reached in any specimens. In the thinner rods the ratio was not quite 70%, and decreased in the 30-mm. rods to 50-58%. The elongation at fracture is in all cases better than the required minimum of 8-10%, and notch-impact strength was in each case higher than the prescribed 7.5 m.-kg./cm.^{2}, the values ranging between 8 and 17.

Metallographic examination was made of polished sections etched with alcoholic nitric acid; the rods with the lowest and highest tensile strength of each type were selected. Generally speaking, the hardened specimens had a fine martensitic structure. The appearance of larger ferritic spots was used as an indication that the quenching temperature was too low. The quenching temperature should be that required for the higher carbon carburized case, but it should also be higher than the Ac_3 temperature of the uncarburized core. Differences in the martensitic structure found in bars of different diameter indicate that the quenching temperatures should apparently be higher for larger diameters. [Aside from its debatable effect on cooling rate and its likely assurance of complete carbide solution, a higher quenching temperature would, of course, give a coarser austenitic grain size and hence deeper hardening, provided the steel in question had sufficient coarsening propensity.—F.P.P.]

The relations between hardness and tensile strength were evaluated statistically from the numerous tests. The frequency curves of the ratio of tensile strength to Vickers hardness for the different materials are asymmetric and show a maximum at a ratio of 0.35 (*i.e.*, the greatest number of observations for any one ratio occur at this ratio). The frequency curve for the ratio of tensile strength to Brinell hardness is more uniform and shows the same number of observations for 0.35 and 0.36. In order to have an immediate visual comparison of all examined steels, a chart is made up showing the maximum and minimum values of tensile strength and notch-impact strength for bars of diameters from 0.2 to 2.4 in. In no case were brittle fractures observed in the notch-impact tests. Ha (2a)

Heat Treating Artillery Shells

THEORY AND PRACTICE OF THE HEAT TREATMENT OF ARMOR-PIERCING PROJECTILES ("Théorie et Pratique du Traitement Thermique des Projectiles D'Artillerie Perforants") M. J. OBREMSKI. *Mem. Art, Francaise*, Vol. 18, No. 2, 1939, pp. 391-411.

The remarks in this article pertain particularly to artillery projectiles and not to small arms armor-piercing bullet cores.

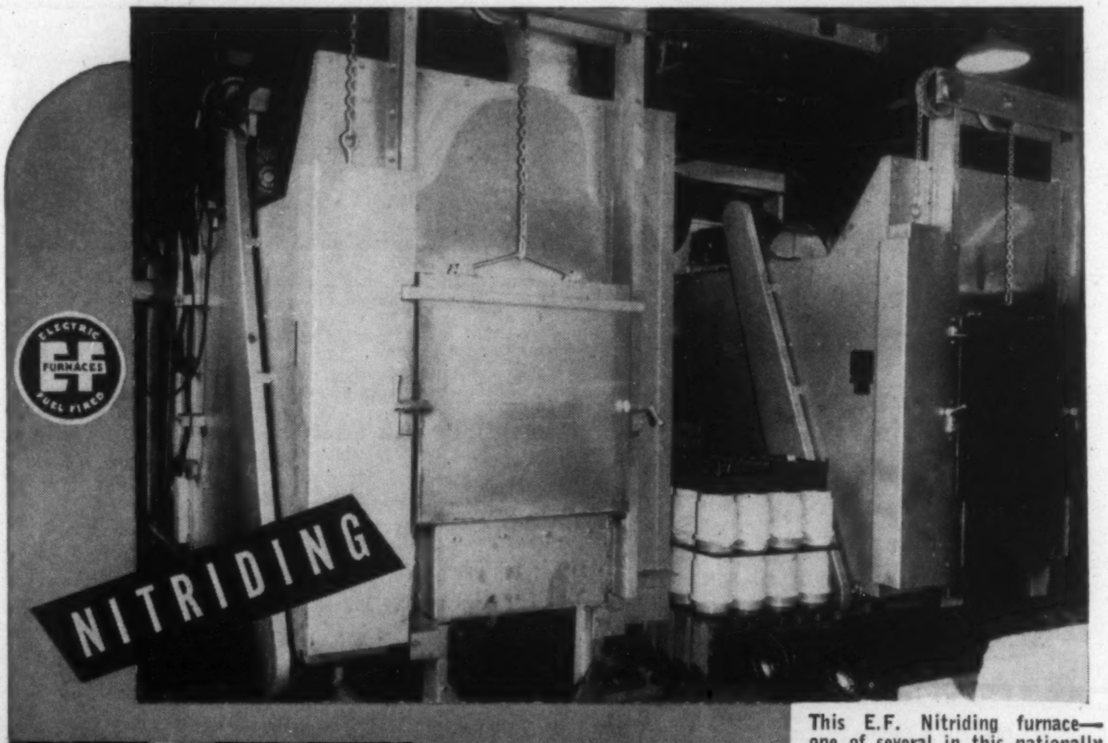
In accepted practice it is necessary that the point and nose of the projectile be hard and that this hardness diminish gradually toward the inside and base of the projectile. This condition permits the hard nose to penetrate armor and leaves the body sufficiently tough and ductile to withstand the enormous stresses encountered as the projectile works its way through the plate.

The several methods of obtaining the desired variation in hardness include:

(a) Heat entire shell above A_3; quench; draw differentially.
(b) Same as (a) except quench differentially and draw differentially.
(c) Heat nose above A_3, body below A_1; quench completely.
(d) Same as (b) except quench nose section only.

The author favors method (d) because it is easier and more certain in actual practice. The recommended procedure is to use a salt bath and immerse the nose of the projectile to such a point that the desired results will be obtained. Preliminary work involves determination of the critical temperatures for the steel being used and experimental determination, by means of thermocouples placed at several points in a shell body, of the zones heated above A_3, between A_1 and A_3, and below A_1. The use of methods (a) and (b) is discouraged because, in the type of steel under discussion, complete quenching from above A_3 involves the possibility of quenching cracks.

The factors that control the operating details and the results obtained are given as the depth hardening properties of the steel, the temperature spread between A_1 and A_3, the critical cooling velocity, the value of hardness obtained by quenching, and the thermal conductivity of the steel.



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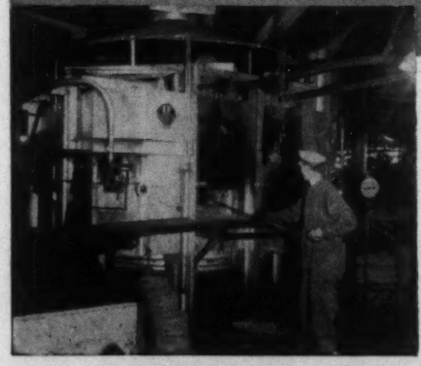
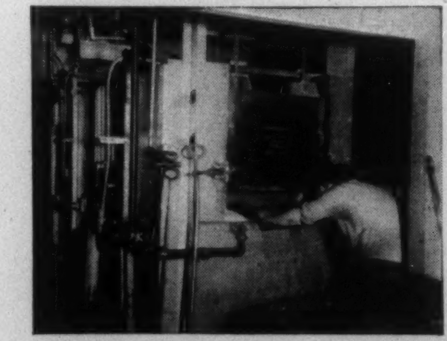


An E.F. Fuel Fired Rotary Furnace—used for normalizing and hardening—in the Wright Aeronautical Corp. plant.



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Steels used for small armor-piercing bullet cores should be chromium and tungsten steels high in carbon and low in manganese [percentages not given]. Chromium-nickel-molybdenum steels are recommended for artillery projectiles for attack against armor. DJM (2a)

Welding Manganese Steels

"Welding Procedure for High-Manganese and Nickel - Manganese Steels". C. M. Magee (Assoc. American Railroads) *Welding Engr.*, Vol. 24, Dec. 1939, pp. 32-35. Practical.

Manganese steel, because of its hardness and toughness, is being used more extensively in railway track work. An outstanding feature is its great susceptibility to work-hardening properties, which is what makes this steel so well adapted to track work. The development of a process for welding manganese steel castings has been valuable in railway work and affords an interesting example of the application of welding to industrial problems.

The first successful type of manganese steel welding in railway frog work consisted of making the weld with high-manganese rod, followed by quenching the deposit with water. The weld was placed in rectangular pads, peened and quenched. The addition of 3-5% nickel to the high-manganese rod gives an air-quench rod. The service performance of nickel-manganese welds on high-manganese castings has been fairly satisfactory. Some railroads have applied a base layer with stainless steel electrode, building up on this with nickel-manganese.

Comments from several welding engineers are included. T. L. Borman (Teleweld Inc.) advocates the use of a bare nickel-manganese electrode. Russell E. Long (Hollup Corp.) believes that a lightly coated nickel-manganese electrode is best. Jonathan Wolfe (Chicago Surface Lines) advocates the straight high - manganese coated electrode, using a water quench. These controversial points require further investigation. CEJ (2a)

Gas Welding Chromium-Molybdenum Steel Tubes

The Welding of Chromium-Molybdenum Steel Tubes ("Ueber die Schweissung von Rohren aus Cr-Mo-Stahl") P. Wimmer. *Autogene Metallbearbeit.*, Vol. 32, Dec. 15, 1939, pp. 345-352. Research.

Chromium-molybdenum steel tubes are widely used, particularly in structures subject to very high stresses. Such tubes have outside diameters of 25-34 mm. and tube walls 0.75 to 2 mm.; their composition is about 0.25% C, 0.60 Mn, 1.0 Cr and 0.23 Mo. They have an ultimate strength of about 114,000 lbs./in.^{2} and an elastic limit of about 100,000 lbs./in.^{2}

Special attention must be paid to the quality of the welding rods for gas welding, which is ordinarily employed for joining tubes, to avoid having the joints weaker than the tubes themselves or making them too hard. Plain carbon steel welding rods resulted in welds of about half the strength of the tubing; a rod of the same composition as the tubes gave welds as strong as the tubing, but the welds were too hard and less tough. "Half-alloy" rods (rod with half the alloy content of the tubes) were not fully satisfactory.

A special alloy rod of the following analysis was developed: 0.23% C, 0.86 Mn, 0.85 Ni and no Cr or Mo. Very exhaustive tests (with 85 mm. long specimens) showed that with unalloyed welding rods the elastic limit was only 84% and the ultimate strength 77% of those of the parent metal, while with alloy rods the elastic limit of the weld was 100% and the ultimate strength 95% of the values for tube material. The tests also gave good results with welding rods of the same composition as the tubes. Bending tests gave best results for the special alloy rod and poorest for the rod of same composition as the tubes.

The special alloy rod gave the toughest welds, and the springiness was much higher than for either the unalloyed or the tube-composition rod. This nickel-bearing rod is therefore of particular advantage for welds that cannot be heat treated subsequently, as welds made with it do not air-harden and are tough. Ha (2a)

2b. *Non-Ferrous*

Welding Aluminum Castings

"Welding Aluminum Castings." *Foundry Trade J.* Vol. 61, Nov. 2, 1939, p. 302. Practical.

A large number of castings are supplied in the heat-treated condition, and welding these castings will partially destroy the effect of the heat-treatment. Unless facilities are available, therefore, for re-heat-treating the castings after welding, welding of such castings is not recommended.

Of the various casting alloys, the aluminum-silicon group are the easiest to weld, followed by the aluminum-copper group. The aluminum-magnesium alloys are the most difficult to weld satisfactorily. If the casting is large, with intricate sections, it should be preheated slowly and uniformly to between 370° and 430° C. in a suitable furnace prior to welding. If the casting

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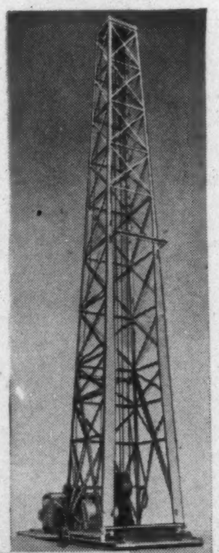

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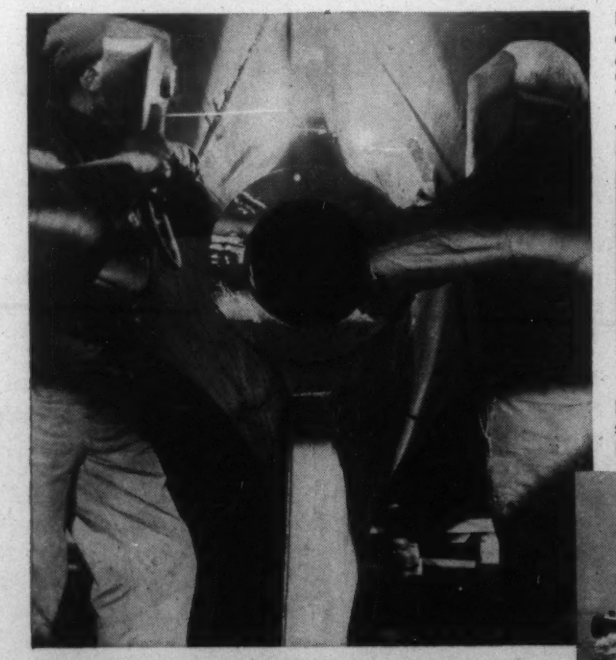
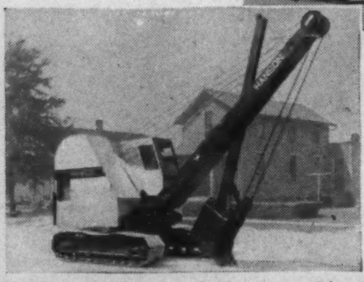


Vertex provides speedy construction of tugs, built by Ira Bushey & Sons Co., Brooklyn, N. Y.



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is small, or if the weld is near the edge and in a thin-walled section, the casting may be preheated in the region of the weld by means of a torch flame. Broken pieces should be tack welded into place as soon as the casting has been preheated. The actual welding should begin at the middle of the break, and welding should be done toward the ends.

For welding ordinary castings the 5% Al-Si alloy or Al-Cu-Si alloy welding rod is generally used. However, in the case of heat-treated castings, a welding rod of the same alloy as the castings is to be preferred. In the welding of large castings in which the area to be welded is quite large and easily accessible, welding rod is often dispensed with and the molten metal added directly from a small ladle, using metal of the same analysis as the castings.

Such poured welds are recommended for filling large holes and cracks. A form or jig of fire clay, plaster of Paris, or metal is fitted around the hole or crack. After the casting has been preheated, the flux is brushed on the faces to be welded and the area to be welded is held at the proper temperature by means of a torch. Molten metal at not over 710° C. is then poured into the weld; the flux and included oxide will immediately float to the surface and can easily be skimmed off. AIK (2b)

Making Brass Cartridge Cases

"CARTRIDGE CASE MANUFACTURE." L. H. CAMPBELL, JR. (Frankford Arsenal) *Army Ordnance*, Vol. 20, Jan-Feb. 1940, pp. 239-243. Descriptive.

Small arms production is no exception to the industrial manufacturing axiom that product specifications must be rigidly met and the number of operations kept to a minimum. But of even more importance from the ordnance viewpoint are the time required to set up an industrial plant for large-scale production of a given item and the production time per unit after production has begun. The speed with which industry can supply vital munitions to its army at the start of a war may determine its outcome, and this speed is one of the factors arsenal operations are intended to improve. Quality of product is vital, too, but actually a balance must be struck between performance in the field and speed of production.

This article discusses improved production methods of brass cartridge cases that reflect reductions in (1) the time required to swing into industrial mass production in an emergency, (2) the number of skilled workmen required, and (3) costs. The function of a cartridge case is to hold the propellent charge of powder and, on firing, to obturate or prevent the escape of gases through the breech of the gun. The cartridge-brass (70% Cu, 30% Zn) used for the disc from which the case is formed is admirably suited for the purpose.

The steps in the production of cartridge cases for the 75-mm. field gun, at the rate of 3,750 per 8-hr day, are 21 in number, starting with a carefully inspected brass disc 0.45-in. thick and 5.415 in. in diam. Cupping on a 225-ton press (cup dimensions are 0.2 in. thickness, 2.5 in. wall length; the operation actually requires only 125 tons pressure) is followed by an anneal at 1150° F. with water-spray cooling, then by a pickle in 5% sulphuric acid to remove scale and a thorough wash to prevent future season-cracking. Bright annealing, to eliminate the pickling operation, is not used because "the slight residual carbon deposit acts as a necessary lubricant in the subsequent drawing operation."

A 150-ton mechanical press, operating at less than 75 tons pressure, accomplishes the first draw, by which the thickness is reduced to 0.093 in. and the wall length increased to 4.75 in. Annealing, pickling and washing are followed by the second draw to 0.043-in. thickness and 8.875-in. length, requiring less than 35 tons pressure. The third and final draw, after annealing and pickling, is performed on a 50-ton hydraulic press using less than 20 tons pressure, and results in a thickness of 0.032 in. and a length of approximately 16 in.

A special trimmer is used to trim about 1.5 in. from the open end of the case to remove the most highly stressed metal, found in this region. The head of the case is formed from a crescent-shaped excess of metal left in the base of the cylinder by the previous drawing operations. In heading the case, with one application of power (675 tons pressure from a 1,000-ton dial-feed press) there is formed simultaneously not only the head but also a boss in the interior of the head, with an indentation. The metal of the boss is thus additionally cold-worked to secure the maximum hardness, so as to provide a primer set that will assure maximum life against gas blow-back around the primer within the head, when the complete round of ammunition is fired.

Before tapering, the possibility of cracking during the process at the mouth end and in the body is eliminated by a special anneal; the body is heated by immersing to within 4 in. of the head in a salt bath at 950° F. This removes all strains and softens the mouth and neck. During firing

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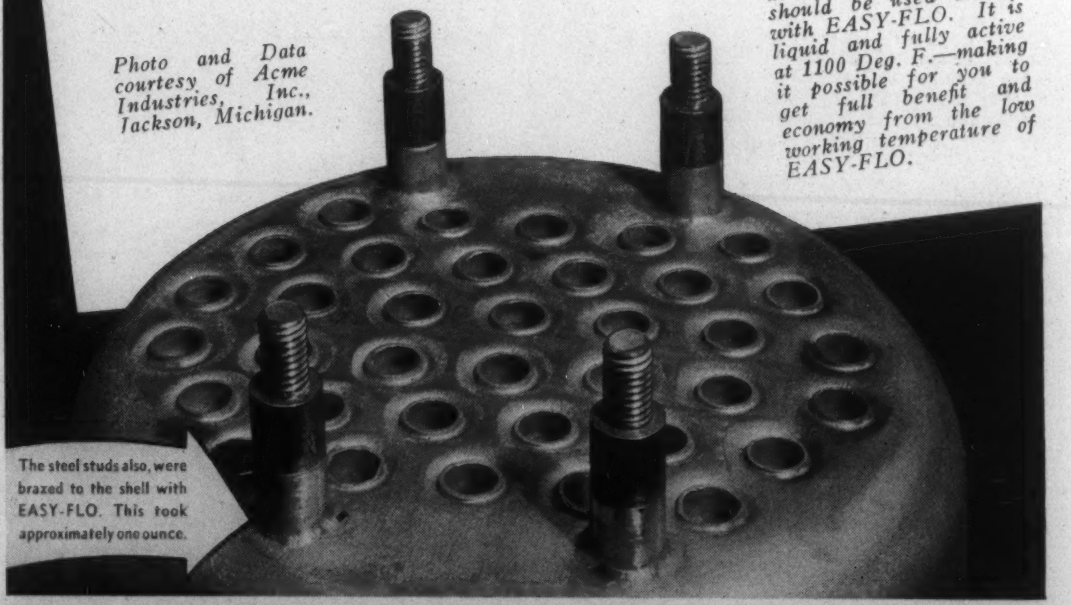

The steel studs also, were brazed to the shell with EASY-FLO. This took approximately one ounce.

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of the cartridge case the metal is worked and becomes hardened; if too many rounds are fired between annealing and resizing, longitudinal splitting at the neck or mouth occurs. Tapering of the case and forming of the mouth to accommodate the shell to be fitted therein are followed by machining (5 operations) of the head on a multi-spindle machine. After stamping the size, model, etc., on the base, the mouth is annealed to a height of 2 in. in a salt bath for 2 min. to provide softer metal for crimping. To avoid season-cracking during storage a low-temperature stress-relief anneal in a controlled atmosphere is now applied.

During the past year the introduction of the use of carbide dies in the drawing operations improved finish-quality of the case and enormously increased die life—enough to offset the added expenditure several-fold. From the defense standpoint this is important because it tends to reduce the load on the tool room and the number of skilled tool- and die-makers required for the production of this item. Better die design, and use of variable-speed hydraulic presses have permitted the use of drawing speeds up to 25 or even 35 ft./min.

Of major significance, because of the smaller number of presses, annealers, picklers, etc., required in an emergency, is the reduction accomplished in the number of draws to make a case. The older method required 6 draws; the present method, by virtue of proper design of dies and redistribution of volume of metal flow between draws, requires only 3.

Experiments are now underway to determine the feasibility of fabricating the cartridge case (1) of brass tubing, suitably secured to a brass base; (2) of steel tubing, secured to a steel base; (3) of molded plastic; and (4) of plywood.

All this is a natural part of the Arsenal's function, as a "production laboratory," of developing rapid manufacturing operations for essential military items that general industry can adopt on a large scale [and in one awful hurry] if war should come.

FPP (2b)

Extinguishing Magnesium Fires

Extinguishing Magnesium Fires ("Magnesiumbrände und ihre Bekämpfung") J. A. Pieper. *Metallwirtschaft,* Vol. 18, Oct. 13, 1939, pp. 833-835. Descriptive.

Improperly handled magnesium or Mg alloy shavings or powder from machining operations can easily be set afire. Sand or cast iron chips will put out a small fire by smothering. The action, however, is slow and expensive machines can be ruined before the fire is extinguished. The use of water on burning magnesium is dangerous and only accelerates burning. Carbon dioxide, carbon tetrachloride and methyl bromide are unsatisfactory. A magnesium-fire extinguisher has been developed in Germany and is sold under the name of "Minimax-Special Magnesium Extinguisher." The extinguishing medium is called "Magnexin" and apparently has a mineral-oil base. No further details as to its nature are presented. The extinguisher itself is generally of 10-liter capacity. A pressure of 8 to 10 atm. provided by a hand pump supplies the motive power. The extinguishing medium is discharged through a long tube equipped with a nozzle. This extinguisher was developed for establishments where much machining of magnesium is done. The medium is chemically neutral and thus will not damage expensive machinery.

Ga (2b)

Age-hardening of Cold-worked Aluminum-Magnesium Alloys

Influence of Cold Working on the Rate of Precipitation of Supersaturated Aluminum-magnesium Solid Solution ("Die Ausscheidungsgeschwindigkeit übersättigter Aluminium-Magnesium-Mischkristalle in Abhangigkeit von der Kaltverformung) H. Vosskühler. *Metallwirtschaft,* Vol. 18, Nov. 3, 1939, pp. 873-877. Original research.

The influence of cold work on the tensile strength, yield strength, elongation, and electrical resistance of two aluminum alloys containing respectively 8.76% and 3.65% magnesium was studied on alloys that were aged at 200° C. for times up to 1000 hrs. after being cold worked 0, 20, 40 and 60%. The curve of tensile strength *vs.* time for the 8.76% Mg alloy showed three different trends for the cold-worked specimens; First, the tensile strength decreases because of recovery, then it rises because of aging and finally it drops again because of coagulation of the precipitate.

From the elongation curve only the effect of increased elongation because of recovery and the decrease due to aging can be noted. The yield strength curves follow those of tensile strengths except that the cusps do not correspond with those of the tensile strength curves. The cold worked samples showed a higher yield strength after 1000 hrs. than the unworked samples. Electrical resistance measurements showed little effect of recovery but did follow the course of precipitation.

The curves for the 3.65% Mg alloy are similar to those of the 8.76% Mg alloy except that the various stages are much less pronounced. The elongation curves after rising because of recovery do not drop, as very little precipitation can occur in this alloy.

GA (2b)

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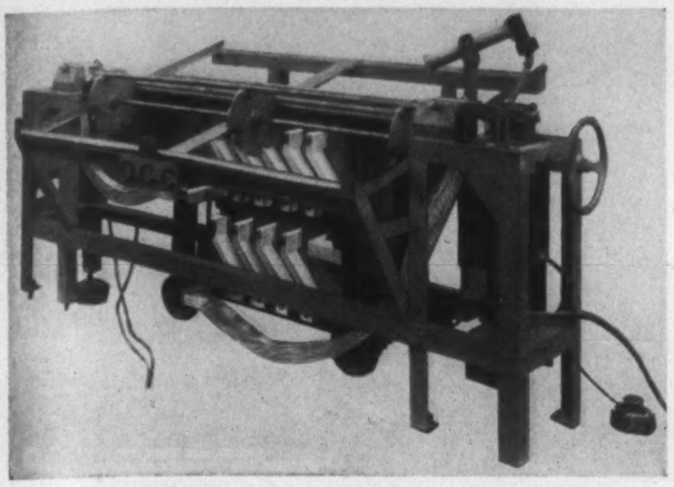

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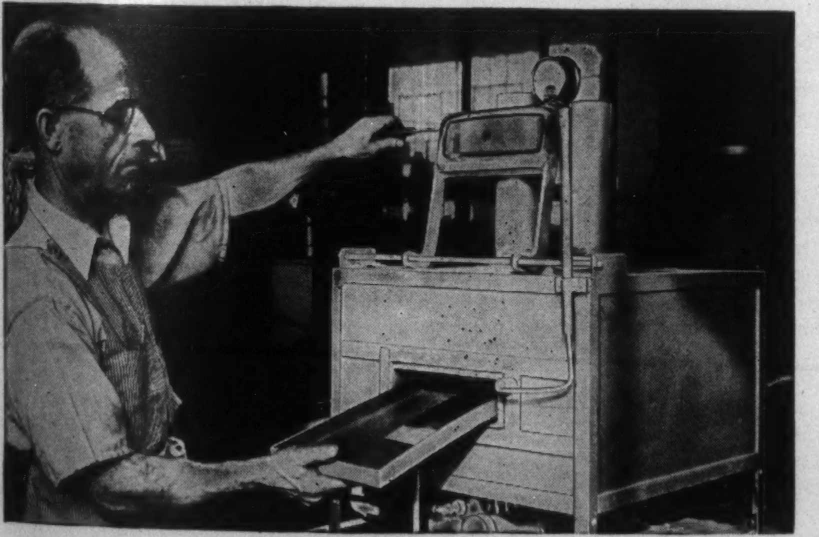

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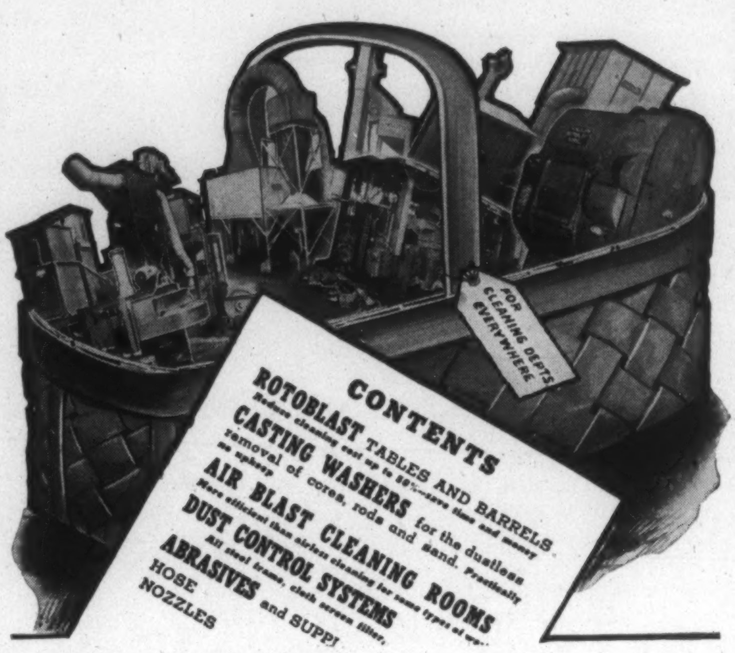
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Scratches and Corrosion

"ELECTROCHEMICAL STUDIES OF THE CORROSION OF STEEL AND MAGNESIUM IN PARTLY INHIBITED SOLUTIONS." L. J. BENSON (Univ. Pittsburgh), R. H. BROWN, & R. B. MEARS (Aluminum Res. Labs.) *Trans. Electrochem. Soc.*, Vol. 76, Preprint No. 22, 1939, 11 pp. Original research.

The corrosion of steel and of magnesium was studied by a method which permitted the isolation of anodic and cathodic areas. One specimen was covered with wax, and from 1 to 20 scratches were made on the surface. These scratches acted as anodic areas when the specimen was immersed in a salt solution. The cathodic areas consisted of specimens having a smooth surface. A scratched specimen and a smooth specimen were immersed in a salt solution, and the current flowing between them was measured.

Also, the potential of each specimen was measured with and without current flowing. Steel specimens were immersed in 0.001 *M* KCl inhibited with 0.0075 *M* K_2CO_3, and magnesium specimens were immersed in 0.001 *M* NaCl inhibited with 0.238 *M* NaF. The addition of the inhibitor was necessary to prevent general corrosion and to restrict the anodic areas to the scratched specimens. The measurements of current and potential were plotted as a function of the number of scratches composing the anodic areas.

The total current of a corrosion cell increased as the number of scratches increased, but the current per scratch decreased. The potential of the short-circuited cell became more negative as the number of scratches increased. Although there was polarization of the anodic and cathodic areas of each metal, the corrosion was essentially under anodic control. In the corrosion of magnesium in the NaCl solution, the NaF increased the potential difference between anodic and cathodic areas. Since the NaF acted as an inhibitor, this increase was more than offset by increased polarization. AB (3)

3a. Ferrous

Chromium Steel Castings

"CHROMIUM STEEL CASTINGS," E. K. SMITH (Electro Metallurgical Co.) *Metal Progress*, Vol. 37, Jan. 1940, pp. 49-54. Descriptive review.

One of the most interesting developments in the past few years is the increase in production and application of steel castings containing about 1% chromium. These are being used where resistance to wear and abrasion, but at a minimum cost, is sought. An especially valuable property of this steel is its ability to withstand differential hardening. For example, a wheel may be cast of this composition, generally with a small amount of vanadium or molybdenum; suitable heat treatment softens the metal in the center, giving excellent resistance to shock, while the rim can be quenched to at least 400 Brinell for resistance to wear and abrasion.

Other instances are cited in which unusually good service was obtained from 1% chromium steel castings containing small amounts of other elements, such as molybdenum and vanadium. For example, S.A.E. 4150 castings containing 1% chromium, 0.20% molybdenum and 0.50% carbon, oil-quenched from 1650° F. and drawn at 700° F., have a Brinell hardness of 450 and are unusually resistant to sand abrasion and impact.

Even more resistant to abrasion, although somewhat more expensive, are the 3% chromium steels, usually with ½% molybdenum added for toughness and prevention of embrittlement, or with small amounts of vanadium for toughness. Simple heat treatment gives a wide range of properties; machinability is excellent in the annealed state. For high hardness, differential quenching or flame hardening is available. This steel is now widely used for guides, crusher parts, rolls, rails and wheels—wherever a combination of resistance to wear, abrasion and mild corrosion is required.

Castings of the familiar 4-6% chromium composition are most frequently used in connection with the 4-6% chromium steel seamless tubes, and in similar applications. Usually either 0.5% molybdenum, 1.0% tungsten or 1.5% silicon (for scaling resistance) are also present. Heat treatment is important, as these steels are decidedly air-hardening. Normalizing at 1650° F. with a draw at 1200° F., or double normalizing, is customary. Castings of this steel are widely used, particularly in the oil industry for such things as return bends. Their use is attractive wherever obsolescence would scrap the equipment before more expensive stainless steels would fail.

Of the chromium-nickel steels, the 15% chromium, 14% nickel steel is giving good service in valve stems, with carbon about 1% and silicon about 3%. Thirty-five % nickel, 15% chromium is familiar as heat-resistant castings. Eighteen-eight castings have found an important new application as manifolds in heavy duty automobile engines. The 29/9 chromium-nickel composition, often with 1% molybdenum, is being used in even larger tonnages; castings tend to be sounder than 18/8 because the carbon can run higher in 29/9, and machinability is appreciably better. The 29/9 composition gives slightly higher strength and lower ductility than 18/8.

Of the "special" chromium steels in the form of castings, the 24% chromium material with 6% tungsten, 0.15% vanadium, 2.25% carbon and 0.30% silicon finds growing application because of its good resistance to wear at high temperatures. An interesting recent development has been the addition of 1-3% chromium to Hadfield's 12-14% manganese steels to give a material that will have sufficient intrinsic hardness and abrasion resistance for applications in which the steels have insufficient opportunity to work-harden rapidly. To avoid excessive reduction in ductility, carbon is usually dropped to 1% and 1-2% copper or nickel, with or without molybdenum, is added.

Columbium additions to chromium steel castings seem to reduce the impact strength of the high alloy stainless steels, but not enough to render the material unsatisfactory for many types of service. Columbium additions to lower-chromium (5%) castings have produced a drastic reduction in impact values.

In many installations, particularly in the oil fields, use of high chromium (over 20%) steel castings has been indicated but avoided because of large grain size and tendency towards porosity. Steels containing 0.14-0.16% nitrogen, added in nitrogen-bearing ferrochromium, are for all practical purposes free of these disadvantages, and their use is spreading. (3a)

Castings or Welded Steel?

A Composite

There probably have been no more prolific writers among engineering authors than those interested in describing designs and structures in which castings have been replaced by welded assemblies. The art of welding has improved tremendously in the last few years, and there has been a natural and large expansion in the use of welding as a fabricating method. Often, though certainly not always, redesign for welding has been at the expense of cast iron or steel castings. But in many cases brand new products that never could have been made with castings are designed for welding, so that there is no "replacement." In other instances, welding has simply replaced other joining methods, such as riveting.

In other, often undescribed cases the designer considers both forms and selects

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castings, for cast ferrous metals are, generally speaking, much better products than they were when the welding boom started. In still other instances, the properties attainable in modern gray iron, for example, are so attractive that welded structures have been redesigned to use cast iron in place of welded steel. Today, the competition for the design engineer's favor is keener than ever, and cast iron seems definitely to be holding its own.

A typical case of redesign for welding is described by R. H. ZEILMAN of the Thew Shovel Co. ("Power Shovel Turntable Bed," *Welding Engr.*, Vol. 24, Nov. 1939, pp. 29-31; Dec. 1939, pp. 20-23). Previous to July 1937, the rear bed of the turntable of the power shovel in question consisted of a U-shaped low carbon steel casting weighing about 570 lbs. The centrifugal and inertia forces in swinging a load present a big problem in design, because these loads develop tremendous strains on the rear bed, particularly at its connections to the front bed. The bulk and shape of the casting were reflected in high foundry costs, because the 570-lb. casting required a 9,700-lb. flask. Cooling cracks also necessitated repair-welding on the casting.

Thus the economy in material cost of a welded bed over a difficult casting was the first advantage considered in design of an all-welded structural steel rear bed. Economy was also offered in the machining operations, which on the casting were of considerable magnitude. The following advantages were offered by redesign: Lower material costs, reduction of machining time, freeing of machine tools for other uses, a better location of boom derricking drum, and reduction in weight over the previously used casting.

The first step in the production of the structural welded rear bed is to assemble the raw materials in the form of rolled steel shapes and plates. After proper laying out, these parts are prepared by shearing, machine flame-cutting or by hand torches, whichever the shape of the piece and economy dictates. Following the shaping of the pieces, all the holes required in the final bed are laid out and drilled on drill presses before assembly. Perfect alignment of all parts is essential, and, therefore, special welding fixtures must be used. The welded assembly weighs 415 pounds, a reduction of 155 pounds as compared to the casting previously used.

Another interesting instance of redesign for welding, this time involving the replacement of cast iron, is reported by M. L. SMITH ("Combine Thermit and Arc Welding in Fabricating Mill Pinion Housing," *Welding J., N. Y.*, Vol. 19, Feb. 1940, p. 97). Lubrication troubles experienced with cast iron housings of blooming mill pinions led Andrews Steel Co. to develop a housing of rolled steel fabricated by welding. The finished pinion housing weighs 22,500 lbs. Two U-shaped central members were flame-cut from 8-in. plates and then thermit-welded together, giving a U-shaped piece of 8x27 in. section at the weld. All other members, flame-cut from 1.5 to 8-in. plate, were arc-welded to the U-shaped component.

But sometimes welded assembly is found to be less satisfactory than cast iron. An editorial in *Foundry*, Vol. 68, Feb. 1940, p. 21 cites remarkable increases in tensile, transverse and compressives strengths of cast iron that have been achieved in recent years, as well as improvement in machinability, wear resistance, corrosion resistance and high temperature properties. The intrinsically high damping capacity of gray iron is receiving deserved recognition from engineers concerned with the design and construction of machinery. The editorial states that the successful development of new markets and the recapture of some business previously lost to competitive products by the foundry industry is a definite trend.

A specific example of such replacement of welded structures by cast iron is given by E. V. CRANE of E. W. Bliss Co. ("Changing from Welded to Cast Frame Construction in Press Design," *Machinery, N. Y.*, Vol. 46, Jan. 1940, pp. 159-161). His company, a manufacturer of heavy presses, has made direct comparative studies of the manufacturing economies and performance record of two functionally identical presses—one made by welded assembly and the other from iron castings. The use of these presses side by side in the same plant led to the conclusion that for heavy presses, where rigidity of construction is all-important, iron castings of the required engineering properties are more satisfactory than any other commercial material.

The cost figures for these presses show that, while about the same weight was used in both cases, the cast iron construction cost, all together, $800 less than the welded steel job. The more satisfactory service performance of the cast frame press is attributed in this case to the excellent vibration damping capacity of the cast iron—a vital necessity for materials used in punch press construction.

Design tendencies as applied to heavy duty machinery of all types are said to have followed a slowly changing curve—beginning with the exclusive use of cast iron as a frame material, passing through a gradual but extensive change to rolled steel welded assemblies, and leading back to a reasonable conception of the proper place for both castings and welded fabrication.

Castings and welded assemblies have found this "proper place" in a judicious combination of both metal-forms in housings for heavy reduction gear units made by the Falk Corp., and described by CARLETON CLEVELAND ("Welded and Cast Steel Construction for Large Reduction Units," *Mill & Factory*, Vol. 26, Jan. 1940, pp. 63-66). The housings (for rolling mills) were formerly made from gray iron or steel castings, but since modern rolling mill drives are individual in character, with group drives for one mill differing from those for another, new-pattern cost and production time become excessively high for cast construction.

Present practice is to use simple steel castings for gears, bearing supports and other parts that can be standardized, and then complete the units by using welded construction. In designing a gear case, for example, the engineer may place cast bearing supports in a welded side-wall; or he may go farther and design cast side walls and weld them to rolled steel plate. The flexibility in such combinations of casting and welding result in freedom of design that few machinery builders have achieved.

And for the anxious foundryman, here is an interesting statement by Cleveland: "In no way, however, has this added use of welding practice minimized the importance of the company's vast foundry capacity. Rather should it be said that welding, as carried on in this plant, has increased the work required by the foundry department, where the production of steel castings to be assembled into welded units is more than ever considered as a very worth-while portion of the foundry tonnage." X (3a)

Steel Tubing in Aircraft

"STRENGTH-WEIGHT RATIO IS IMPROVED BY STEEL TUBING". JOHN W. GREVE (Staff) *Machine Design*, Vol. 12, Jan. 1940, pp. 49-50. Descriptive.

Adaptability to modern fabrication methods and relatively high strength-weight ratios have extended the field of application of steel tubing. In airplane design these features are especially necessary, and indicate the great possibilities for this metal-form in the aircraft field.

In one plane the fuselage structure is designed to withstand critical loadings under various flight and landing attitudes of the plane, without, however, using a multiplicity of tube sizes. The fuselage frame assembly consists of an engine mount structure, a forward section, and an aft section, all of which are of welded chromium-molybdenum steel (S.A.E. 4130) tubing and fitting construction, except the lower rear portion of the aft section, which is of aluminum alloy semi-monocoque construction.

Welding is used to connect the other components through fittings with the main tubing structure. A steel tubing structure projecting above the fuselage proper is an integral part of the fuselage frame assembly and forms an overturning structure for protection of the occupants. Other parts are readily secured to the skeleton fuselage frame assembly by means of standard clamps and special brackets. Simplicity, accessibility, repairability and exchangeability are features of this design.

For highest tensile strengths and corrosion resistance, 18/8 stainless steel tubing is used. There are also applications of this material of a heat-resisting nature, *e.g.*, for mounting engines in fuselage of tubular construction. Stainless steel is often used in preference to aluminum alloys, such as 24 ST, because the stainless requires no coating, can be more readily joined (by spot welding) and has a slightly better strength-weight ratio. For long column compression members, the aluminum alloy has some advantages, but for tension members and those subjected to repeated stresses, stainless is more satisfactory.

Tapering tubes with a double taper (tapering from a base-size tube down to both ends) gives a member increased strength per unit weight against bending. In addition to savings in weight of 15-25% on many important parts, there are corresponding savings in assembly costs and weights of fittings and fairings. Tapered tubes are now being applied to landing gear tubes, fuselage parts, engine mount legs and torque tubes. (3a)

Fatigue in Aircraft

A Composite

Fatigue problems in respect to aircraft are discussed in several recent German publications. One of these is a doctor's thesis by Federn on stress conditions and the nature of fracture (A. THUM & K. FEDERN, "Spannungszustand und Bruchausbildung," J. Springer, Berlin, 1939, 78 pp., price 9.60 RM.). Unlike most of the earlier German theses, which contain large amounts of experimental work, this is more in the nature of a correlated abstract.

Considerable space is allotted to discussion of triaxial stresses, the restriction upon deformation when a notch is present, and the fact that the strength of a part or structure is governed not only by the strength of the material but also by the geometric shape. The difference in stress distribution beneath a surface stress-raiser,

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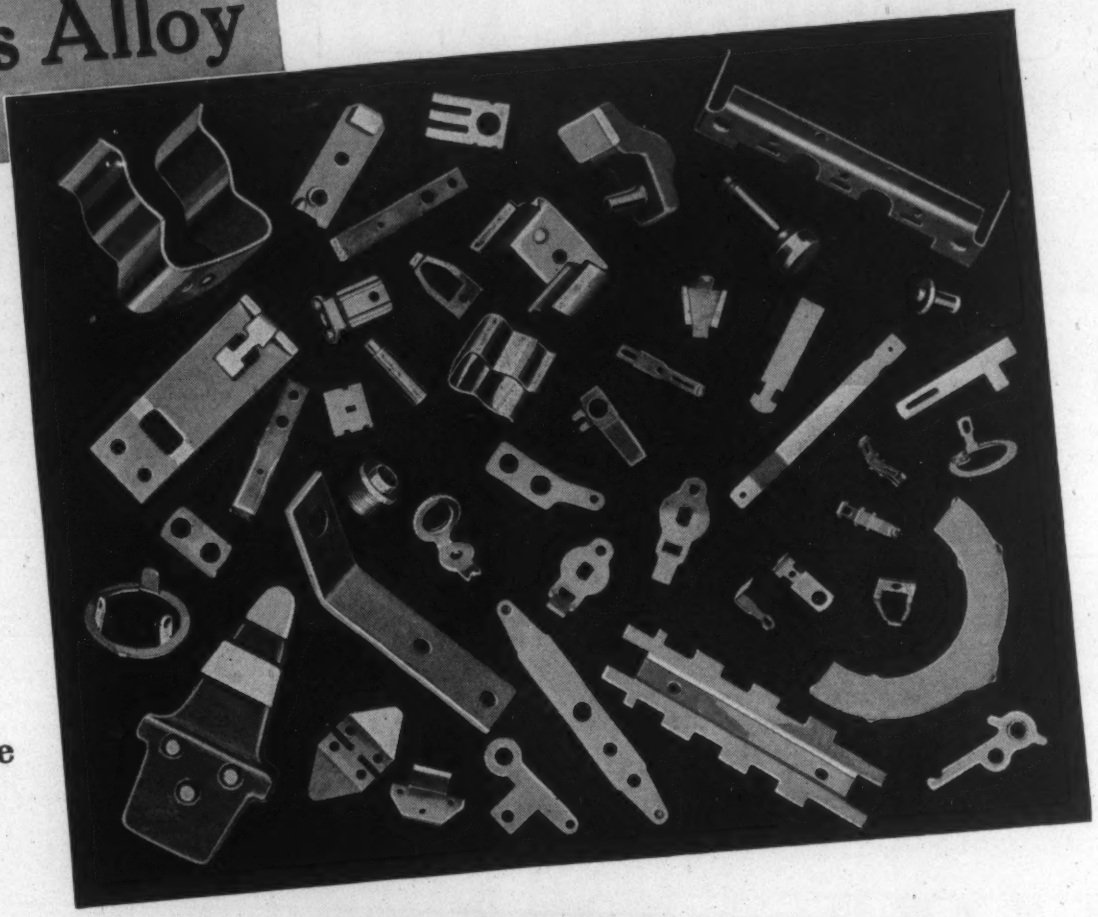

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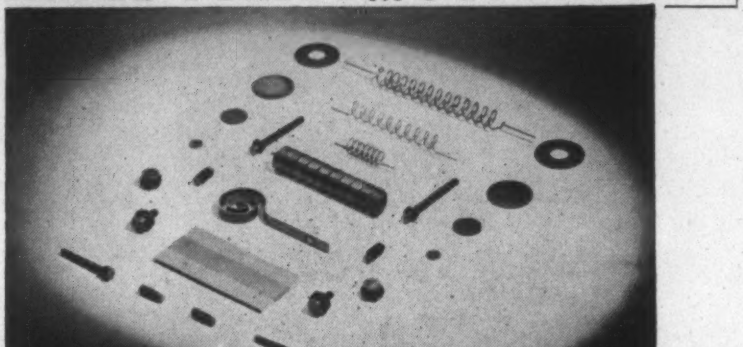

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such as a notch, in axial loading and in bending is brought out. These points have been discussed in English by Haigh (see the digest "Testing Arc-Welded Joints" in this issue, p. MA 156) and in an editorial (also in this issue) on p. A 19. The distribution of stress about a notch in torsion is discussed (somewhat as Smith discussed it in *Univ. Ill. Eng. Expt. Sta. Bull.* Vol. 37, No. 5, 1940) as to whether the fracture was transverse or spiral. Experiments were made in repeated torsion on shafts with longitudinal or transverse grinding scratches, using a hard spring temper, and a soft, low carbon steel.

A terminology is used that is creeping into the German literature on fatigue, by which fractures produced by repeated stress not far above the endurance limit are referred to as fatigue fractures, and those at much higher repeated stresses as "time fractures." In the "time fractures," at stresses above the proportional limit, the scratches created several nuclei for failure or, on a polished specimen, several nuclei appeared and the break was very irregular. This was also noted on the soft steel at stresses below the proportional limit but above the endurance limit, while on the hard steel, in that stress range, spiral fractures resulted. The idea seems to be that by observing a post-mortem fracture, one can say something as to the service stresses which initiated the failure.

The differences in type of fracture are related back to the conditions of restraint upon plastic flow exerted by the geometry of the notches in producing triaxial stress conditions. Very much the same argument is presented in a paper on the time strength and fatigue strength of materials by L. BOLLENRATH ("Zeit- und Dauerfestigkeit der Werkstoffe," *1938 Jahrbuch Deut. Luftfahrtforschung, Lilienthal - Gesellschaft für Luftfahrtforschung*, Hauptsammlung pp. 147-157) in respect to hindrance of plastic deformation. Another point dealt with by Bollenrath is the question, studied very early in the history of fatigue testing, whether a metal can "rest up" from fatigue by having no-load periods interspersed between periods of fatigue loading. It was long ago decided that metal didn't recuperate in this fashion, and Bollenrath demonstrates this for a chromium-molybdenum steel heat-treated to 110,000 lbs./in.^{2} tensile and for duralumin, of 59,000 lbs./in.^{2} tensile. The scatter bands of the S-N curves for each are slightly widened, because of the testing of more specimens, but there is no sign of improvement.

The most interesting part of Bollenrath's article is a discussion of "time fractures" in relation to the damage line, when the cyclic stresses imposed are of varying intensity. A "summation curve" of the stresses is built up on the basis of frequency data. The number of overloads at one high stress range is multiplied by a factor of severity, the number at a slightly less high range is multiplied by a smaller factor, and so on, and these products added. If the cumulative sum does not intersect the damage line, the loading is considered to have been in the safe range. The nigger in the wood pile is, how is one to know what to make each particular severity factor, in order to carry out the mathematical calculation?

O. NISSEN ("Festigkeitsfragen bei der Gesaltung neuzeitlicher Flugzeuge," *Ibid.*, pp. 158-163) tries to approximate these factors by noting the hours and the mileage flown of some old, slow Junkers planes and some newer, faster ones, before the wing spars or spar connections cracked in service, also by laboratory tests of the assembled members. He concludes that retirement from service of parts stressed into the "time-break" region should be on the basis of miles flown, *i.e.*, on the number of alternations of stress rather than on hours. This indicates that the terminology of "time" fractures is a poor one.

H. W. PAUL, seeking data on the necessary time-strength and fatigue strength of aircraft structural parts ("Die erforderliche Zeit-und Dauerfestigkeit von Flugtragwerken," *Ibid.*, Part 1, pp. 274-288) recorded the stresses imposed in flight on aircraft, especially in gusty weather (incidentally, the German word for gust is *Bö*—page Lifebuoy!). He relates these stresses to one corresponding to the endurance limit of the structure as a safe stress, and points out that it is the smaller number of high overstresses, due to gusts, that really governs the life. He winds up by bewailing the lack of information on the high stress end of the S-N curves and on the damage lines of structures under repeated stress, since it is "time-strength" that design really needs to provide.

Particular attention was paid to the high stress end of the S-N curves for chromium-molybdenum steel tubing, by L. BOLLENRATH & H. CORNELIUS ("Zeit- und Dauerfestigkeit ungeschweisster und Stumpfgeschweisster Cr-Mo Stahlrohre bei verschiedenen Zugmittelspannungen," *Ibid.*, Part 1, pp. 549-553). Using 0.25% C, 1% Cr, 1/4% Mo steel tubing, unwelded and butt-welded, they determined the S-N curves for failure over the range 1,000-100,000 cycles

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("time-strength") as well as the endurance limit for 10 million cycles. One series was left as oxyacetylene welded, the other was oil-quenched from 1540° F. and drawn to 1110° F. after welding. The endurance limits, or the stress for a life of 100,000 cycles was not improved by heat treatment, but at higher stresses, *e.g.*, for 1,000 and 10,000 cycles life, the heat-treated specimens were materially better. HWG (3a)

Scale in Cooling Systems

"SUPPRESSING SCALE FORMATION IN COMPRESSOR COOLING SYSTEMS." E. J. MATTHEWS. *Foundry Trade J.*, Vol. 61, Dec. 14, 1939, p. 408. Practical.

Scale formation from cooling water supplies is invariably due to the carbonate hardness of the water. The major part of the scale is composed of calcium or magnesium carbonates, with possibly a little organic matter and silica as well. The following analysis of one such deposit is typical: Calcium carbonate, 92.7; sulphates, 4.2; iron oxide, 1.8; silica, 0.3; and organic matter, 1.0%.

The formation of these carbonate deposits can be prevented by the addition to the cooling water of sodium metaphosphate (1 or 2 parts per million, 1 or 2 lbs. per 100,000 gals.). It has been found that this reagent, even in such small proportion, possesses the property of suppressing carbonate deposition at cooling water temperatures until much higher mineral concentrations are reached.

Recent and extensive experience of this reagent on a variety of similar cooling conditions has shown that not only is fresh scale deposition prevented, but existing carbonate deposits also are gradually removed during the treatment. AIK (3a)

3b. Non-Ferrous

Free-Machining Copper Alloys

"TELLURIUM, SELENIUM AND SULPHUR IN COPPER ALLOYS." H. L. BURGHOFF (Chase Brass & Copper Co.) *Iron Age*, Vol. 144, Dec. 7, 1939, pp. 35-39. Review.

During the last few years attempts have been made to develop free-machining copper alloys that do not suffer from the poor hot-working properties and the tendency to fire-cracking associated with the standard leaded free-cutting materials. Most promising have been copper alloys containing tellurium, selenium or sulphur, some of which have achieved successful commercial use. This article reviews the properties of the new alloys and presents some new data on their serviceability.

At 2192° F., at which temperature copper is liquid, it will dissolve 18.15% tellurium, 4.11% selenium and 1.55% sulphur. These elements are present in solid copper as CuTe, CuSe or Cu_2S; the compounds are said to be insoluble and to melt at 1598°, 2035° and 2111° F. respectively. Melting and casting of copper and copper alloys containing small amounts of these elements are accomplished without difficulty. Such coppers are also readily hot worked and cold worked, although not to the same degree as pure copper.

Useful wrought alloys contain no more than 1% of any of the 3 elements and, within such limits, the tensile strength and hardness of copper and copper alloys are substantially unaffected, although there does seem to be a restraining influence upon grain growth in annealing. Ductility is slightly reduced as the amount of alloying element increases. Sulphur has less beneficial effect upon machinability of copper than either tellurium or selenium. A table is given showing the properties and electrical conductivity values for a series of copper alloys containing tellurium, selenium and sulphur.

With regard to machinability, the ease of cutting increases rapidly for additions of each of the elements up to 0.25%. In tests conducted, the time required to drill a standard hole in ordinary copper is found to be 5 times as long as in copper containing about 0.5% tellurium or selenium, and about 2½ times as long as in copper with about 0.5% sulphur. Sawcut tests show that about 0.7% tellurium in copper yields an alloy equivalent in performance to commercial free-cutting brass (62% copper, 34.75% zinc, 3.25% lead) for this type of cutting operation.

The influence of tellurium on the properties of various copper alloys is similar to its effect on copper. Ductility, as indicated by elongation and contraction of area in tensile test and by impact value, is somewhat adversely affected. The machinability of the tin bronze series of alloys is increased by tellurium to a much greater degree than in the case of tellurium additions to either the 90/10 copper-zinc or the 3% silicon bronze series. Yellow brass of 65% copper and 35% zinc was substantially unchanged in machinability by the addition of 0.2% tellurium. The same was true for 60/40 brass containing 0.98 and 1.76% tellurium.

The first commercial application of copper and copper alloys containing tellurium, selenium or sulphur was a 3% silicon bronze with 0.25-0.5% tellurium. This alloy possessed the high strength characteristics of the silicon bronzes with the superlative machinability conferred by tellurium. Recently a more simple alloy of pure copper and 0.5% tellurium, made in both rod and tube form, has become commercially available. This alloy has good machinability, forgeability and electrical and thermal conductivity. It lends itself to screw machine operation. Excellent hot working characteristics and freedom from fire-cracking provide it with additional advantages over leaded copper and bronze.

Another alloy developed commercially contains 0.5% tellurium, 1.0% nickel, 0.2% phosphorus and 98.3% copper. This alloy is age-hardenable. The heat treatment is accomplished in 2 steps: (1) Solution or softening anneal in the range 1200°-1600° F. followed by rapid cooling; and (2) hardening treatment consisting of reheating at about 850° F. for 1-2 hours. The alloy may be cold worked before or after age hardening. VSP (3b)

Creep of Aluminum Alloys

Definition of Creep Resistance of Aluminum Alloys ("Zur Definition der Dauerstandfestigkeit von Aluminiumlegierungen") F. von Göler & W. Jung-König. *Z. Metallkunde*, Vol. 31, Oct. 1939, pp. 313-317; with discussion. Original research.

There is very little quantitative information on the creep resistance of aluminum alloys. In this investigation the creep properties of the important aluminum-copper-magnesium alloys were studied. One peculiar irregularity was noticed in the creep curves; after 15-40 hrs. a temporary increase of the rate of creep occurs, which disappears again after 150-200 hrs. This effect is attributed to a change of length due to precipitation. Diagrams show the dimensional changes due to aging at 120 to 225° C. at no load, and the rates of creep in relation to (a) load at 150° C., (b) preannealing before stressing at 31,300 lbs./in.^{2} at 150° C., and (c) load at 225° C. (up to 13,000 lbs./in.^{2}) and at 120° C. (32,700-38,500 lbs./in.^{2}).

It is obvious that the precipitation effect has a great influence on the creep/time curves. Tabular evaluation of the creep curves obtained on 78 test rods shows that (1) the rate of creep decreases if it is less than 3x10^{-4}%/hr. between the 25th and 35th hr., (2) the rate of creep first decreases and then again increases if it amounts to over 7x10^{-4}%/hr. during the above mentioned period, and (3) fracture occurs in all cases when the creep rate is over 7x10^{-4}%/hr., but no fracture occurs when the rate is less than 3x10^{-4}%/hr.

The relationship between critical creep rate (10 x 10^{-4}%/hr. between the 25th and 35th hr.) and load shows a marked difference in comparison with steel. The break in the creep rate/load curve of steel is at about 10 x 10^{-4}%/hr., while in the case of aluminum alloys this break occurs at less than 5 x 10^{-4}%/hr. It is concluded that the factor used in determining the "permissible rate of creep" from accelerated creep tests with aluminum alloys should be only one-half as great as that with steel.

Rohn points out in the discussion the importance of the recrystallization temperature. Most creep tests on steel have been carried out below the recrystallization temperature and the creep results obtained between the 25th and 35th hrs. yield clues as to the creep during long periods of time. This does not hold for tests on steel performed above the recrystallization temperature. The complexity of creep test results on aluminum alloys may be due to the fact that their recrystallization temperatures vary greatly. The correlation between short-time and long-time creep tests is not the same for, say, low-alloy structural steels and high-alloy high speed steels. EF (3b)

Calcium-bearing Magnesium Alloys

Some Properties of Calcium-bearing Magnesium Alloys ("Ueber einige Eigenschaften kalziumhaltiger Magnesiumlegierungen") Walter Bulian. *Z. Metallkunde*, Vol. 31, Sept. 1939, pp. 302-304. Original research.

After preliminary laboratory tests on magnesium alloys, to which 0.1-0.3% calcium was added, showed a refinement of grain and increase of yield point, a systematic study was undertaken. Pure magnesium and magnesium-manganese (2% manganese) castings show very coarse grain. By adding 0.13-0.15% calcium the grain was refined to 1/500th of its size in calcium-free material. Additional tests showed that as little as 0.08% calcium sufficed to bring about this effect.

The grain-refining action of calcium is not lost in extrusion. By adding 0.13% calcium to a magnesium alloy containing 2% manganese and 0.3% aluminum, the tensile strength was raised moderately, the yield point increased very notably and the elongation doubled. At certain degrees of extrusion the elongation was noted to be 4-18% higher in the calcium-bearing material. This indicated that the calcium-bearing magnesium alloys may be used as sheets. An effect of calcium on rolling was not noticed. The rolled sheets showed the high yield point of 28,500 lbs./in.^{2}, with an elongation of 18-25%. Bendability was improved by virtue of the finer grain.

Because the magnesium-manganese alloys are the most corrosion resistant among the magnesium alloys, the effect of calcium on this property was studied. A few tenths of a per cent of calcium does not affect the corrosion resistance, nor does it induce season cracking. Weldability was also not impaired by the calcium addition. Although the aluminum-bearing magnesium alloys with 3-6% aluminum are relatively fine-grained, further grain-refinement was induced by the incorporation of calcium. However, no improvement in the physical properties of the magnesium-aluminum alloys could be obtained by adding calcium. EF (3b)

Copper-Base Permanent Magnet Alloy

A Permanent Magnet Alloy with Anisotropic Magnetic Properties ("Eine Dauermagnetlegierung mit anisotropen magnetischen Eigenschaften") H. G. Müller. *Z. Elektrochem.* Vol. 45, Sept. 1939, pp. 674-678. Original research.

An alloy containing 20% Fe, 20% Ni and 60% Cu was homogenized at 1100° C., quenched, and aged at 600° C. for 10-20 hrs., or at 700° C. for ½ hr. After this treatment the alloy has a coercive force of 400 Oe and a remanence of 300 Gauss; with respect to magnetic properties it is completely isotropic. By cold rolling the remanence is increased to 5000 Gauss at 50% reduction, then drops again to 2000 Gauss at 99% reduction. The coercive force does not change up to 50% reduction, then drops more sharply in the transverse than in the longitudinal direction. If the cold-rolled alloy is reheated to 600° C. the remanence and coercive force increase to above the previous maxima; 500 Oe and 5500 Gauss are reached. After prolonged annealing remanence and coercive force in the rolling direction drop again while the coercive force rises uniformly in the transverse direction; thus the anisotropy disappears gradually.

The cause for the anisotropic magnetic properties in the cold-worked alloy is attributed to a stress condition produced by the anisotropic distribution of heterogeneous inclusions. There is no connection with the crystallographically coupled preferred orientation. The increase in coercive force is due to acceleration of the precipitation process and the increase of heterogeneous inclusions, which go hand in hand. RPS (3b)

"Cold Welding" of Metal Contacts

A Composite

Much of the excessive wear of pure metal electrical contacts that seem to possess satisfactory hardness and abrasion resistance has been ascribed to "cold welding"—the phenomenon by which smooth metal surfaces become "welded" together on the application of pressure at temperatures at or somewhat above room temperatures. Studies of this phenomenon as it occurs with silver, gold and nickel are reported in two articles.

Previous work had indicated that silver could not be welded to silver by pressure alone at a temperature below 200° C., the recrystallization temperature of silver. However, G. R. van Duzee & J. M. Thomas of Lehigh Univ. ("Cold Welding of Silver—II," *Trans. Electrochem. Soc.*, Vol. 77, 1940, Preprint No. 6, 9 pp.) demonstrate that pressure welding will occur at room temperature, if the silver has been heated to redness immediately before use. In this investigation the silver strips used were 0.5 mm. thick and the pressures applied varied from 40,000 to 140,000 lbs./in.^{2}

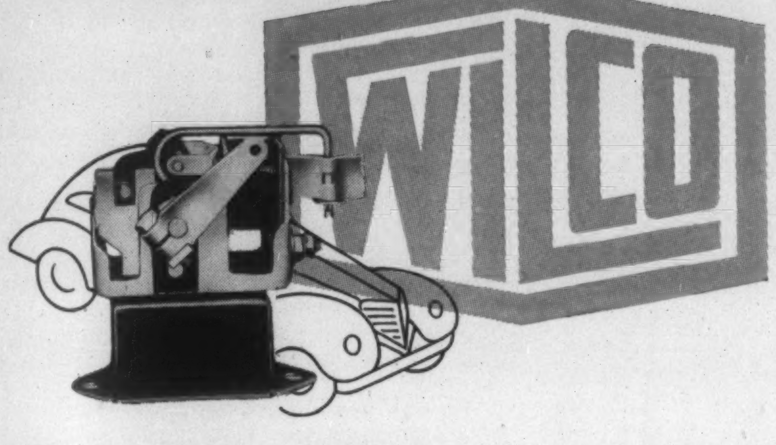
At room temperature welding took place in 30 sec. with a pressure of 70,000 lbs./in.^{2}, if the silver had been preheated; but 2.5 min. at a pressure of 100,000 lbs./in.^{2} were required if the silver had not been preheated. At a red heat, silver can be welded in 15 sec. with a pressure of 40,000 lbs./in.^{2} Fine silver (999.3) was slightly less weldable than spectroscopically pure silver.

The welding of silver powder (300 mesh) under pressures of 60,000 lbs./in.^{2} was also studied. The pellets formed at room temperature were easily shattered by hammering. Those formed at 300° C. withstood mechanical deformation without shattering.

Some observations were made on the cold welding of gold. Two strips of gold which had previously been heated to redness could be welded at room temperature by applying a pressure of 45,000 lbs./in.^{2} for 30 sec., but a pressure of 90,000 lbs./in.^{2} was required if the gold had not been preheated.

The friction of nickel on nickel (in a vacuum) is studied by R. Holm & B. Kirschstein ("Die Reibung von Nickel auf Nickel im Vakuum," *Wiss. Veröff. Siemens Werken*, Vol. 28, No. 2, 1939, pp. 73-77). They found that "cold welding" occurred so readily as to interfere with their "inclination method" of studying frictional adhesion. For such studies they now employ a new method in which force is applied parallel to the contacting faces. Work on nickel surfaces indicates that the numerical value of the shearing strength (in kg./mm.^{2}) at the contacting interfaces is several times greater than the Brinell hardness number. X (3b)

LEADERSHIP!



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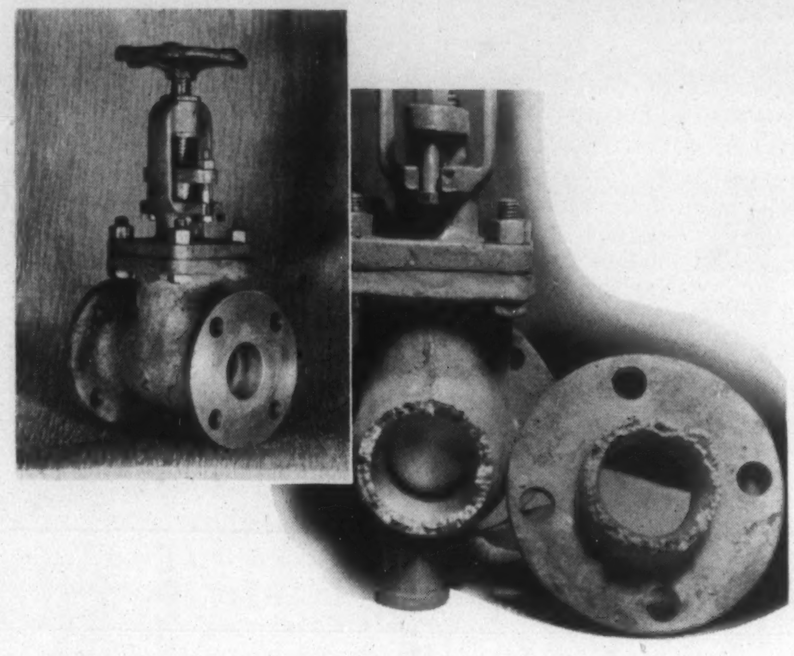

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The oxidizing solution of sulfuric acid attacked the grain boundaries and weakened the metal structure.

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4 Testing and Control

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

Testing Arc-Welded Joints

"Electric Welding as an Integral Part of Structural Design." B. P. Haigh. *N. E. Coast Inst. Engrs. & Shipbuilders*, Adv. Copy, Nov. 1939, 36 pp. Survey.

The properties of welds, and methods of evaluating the effect of welding practice on the joint behavior are reviewed. The remedy to prevent cracking is considered to be sufficient ductility in the weld metal and slow cooling for equalization of temperatures and development of plastic strains that limit the stresses reached in the interior of the deposit. In the completed weld the requirement should be greater ductility than the base metal—rather than greater strength—to ensure that the stress is distributed more uniformly across the section provided to carry the load.

The notched-bar bending tests of welds are of special interest because the stresses below the notch are commonly of the nature of triple tensile stress, tending to cause brittle fracture—even in metals endowed with fair degrees of ductility as judged by other tests that produce stresses more in the nature of shear. Notched-bar tests are of special value for comparing different steels as regards suitability for welding, because the character of the stresses produced during the test has much in common with those produced by internal contraction.

Hardness tests appear to be open to the criticism that limitation of hardness does not necessarily ensure freedom from cracking. The author's opinion is that cracks may occur in the martensite grains during the local volume change when martensite transforms to softer structures. The relation of size of notch-bending-test specimen to the incidence of brittle fracture is discussed from experimental data. These data indicate the proportionately greater seriousness of a notch in the larger specimens. The angle of bend causing fracture was 8 and more than 50 respectively for specimens 100 mm. and 10 mm. square, with geometrically similar notches of 20 and 2 mm. depths, respectively. The author states that "large notched bars are necessarily brittle, even at ordinary temperatures, no matter how toughly ductile the metal may appear when tested in standard small-sized pieces. The danger of cracking arises even in the toughest of steels when the size exceeds certain limiting dimensions, and the safe limits for different steels appears to be a matter of considerable practical importance." The solution to the problem is suggested as the avoidance of heavy forgings, castings or plates that exceed the limiting thickness for ductile bending.

Several photographs are shown of the successive stages in the failure of notched bars in bending. These indicate that a curved region of the bar under the notch is subjected to triple tensile stress and in large bars the fracturing crack originates in the region of triple tensile stress. A notched-disc test is also described for differentiating between tough and brittle welded steels. Brittle welds snap readily but soft mild steels of inferior quality, containing quantities of slag and numerous gas pockets commonly reveal surprising toughness and leave the impression that these well-known faults may not be as dangerous as we often assume. The author considers that the notched-disc offers the greatest opportunities for making direct comparisons between the notched-specimen test and the tensile test. Such tests show that the stresses required to start plastic yield in mild steel, as-rolled or normalized, are greater than the ultimate tensile strength, provided plastic strain has not been previously produced in the metal. The higher yield points that can be determined in tensile tests when suitable precautions are taken to insure that the stresses do not even locally exceed nominal values explain results that would otherwise appear anomalous; for example, that weld deposits appear to be so little affected by porosity and slag inclusions or even cracks, which must certainly produce severe stress concentration.

The "lower yield point" is discussed as to its significance in design and the means of obtaining the value in a tensile test; it is the stress which is placed on the specimen after plastic strain has started, but before it has spread over the whole length of the parallel portion of the specimen. The load is adjusted to rebalance the beam of the machine while plastic strain continues to spread slowly and steadily along the length of the test piece. The lower yield point is therefore defined as that point at which plastic strain, once it has started, continues to spread through the metal to produce effects corresponding to failure while the "higher yield point" might be called the "true" elastic limit or the point at which strain starts locally.

The welding of high tensile silicon steel plates of 0.31% C, 0.79 Mn, 0.83 Si cut from the *Mauretania* was investigated with two manual methods of arc welding and with the Unionmelt process. Bending tests were made on the welded joints and it was noted that the Unionmelt welds gave phenomenal results in bending and fatigue. The results are interpreted as indicating that the silicon steel is weldable without injury.

Fatigue tests on welded joints are described, using the Haigh electromagnetic testing machine for pulsating or reversing loads up to 7 tons. Tests at a frequency of 3000 cycles/min. can be made on full thicknesses of plates in the as-welded condition. The use of higher speed, or the same speed for larger specimens, is considered to lead to misleading results because of the additional hysteretic heating in the metal. The machine is designed to apply the stresses uniformly as pull or push along the whole length and across the full cross-section of the sample and to measure the extreme stresses with precision during the long continuance of the test. The alternating component loads are produced by means of two-phase electromagnets and the steady component loads by means of springs. The author's opinion is that fatigue strength of welded joints can be improved to as much as 50% over values for joints made manually with ordinary electrodes, when special care is used to avoid porosity and slag inclusions. Still better results can be obtained with machine-welded joints because of the larger electrodes and higher currents used.

A discussion of design of welded structures shows that higher strengths with reduced weight are obtained in the welded design. The use of brittle resin coating on test specimens for determining stress and strain relationships is discussed, and shown to give results that indicate the changes that are required in the design to overcome sources of weakness revealed by the method. Resin coatings used in the manner described will largely replace the use of extensometers in experimental work and the use of mathematical analyses based on the laws of elasticity. WB (4)

Measuring Tarnishing

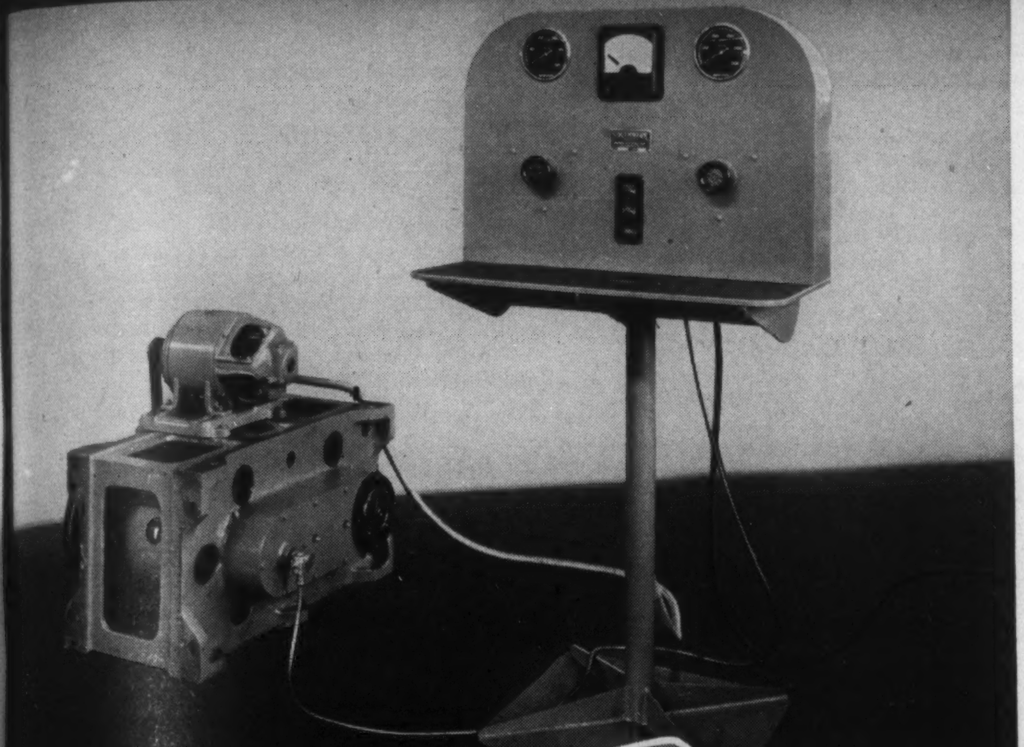
"Tarnish Studies. The Electrolytic Reduction Method for the Analysis of Films on Metal Surfaces." W. E. Campbell & U. B. Thomas (Bell Telephone Labs.) *Trans. Electrochem. Soc.*, Vol. 76, 1939, Preprint No. 25; 22 pp. Original research.

The electrolytic reduction method was refined so as to permit the estimation of the thickness of cuprous oxide films of the order of 1 mono-molecular layer in thickness.

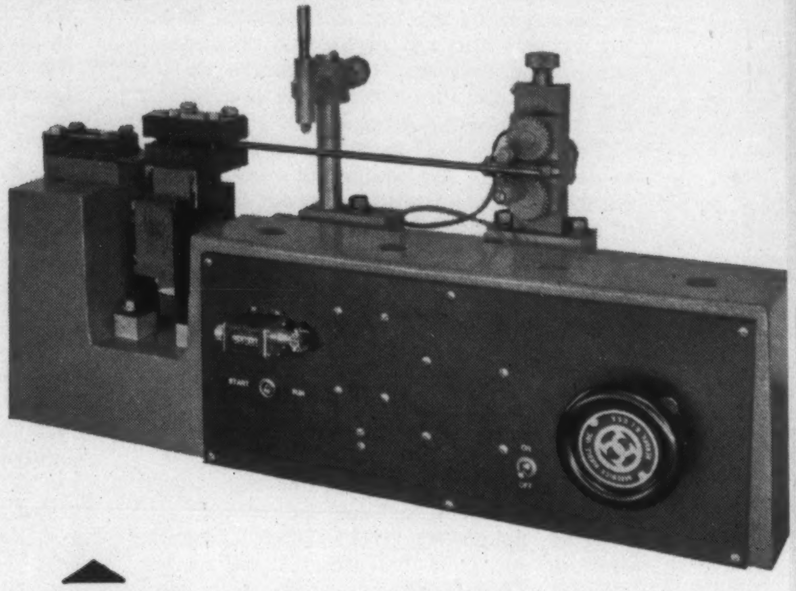
The method consists in making the specimen the cathode in an electrolyte of 0.1 *M* potassium chloride and reducing it slowly by a small current until the potential rises sharply to the hydrogen discharge potential. The film thickness is calculated from the current and the time required for reduction.

Previous investigators used an open cell, but for accurate work a closed cell free from oxygen was used to eliminate the depolarizing influence of dissolved oxygen on

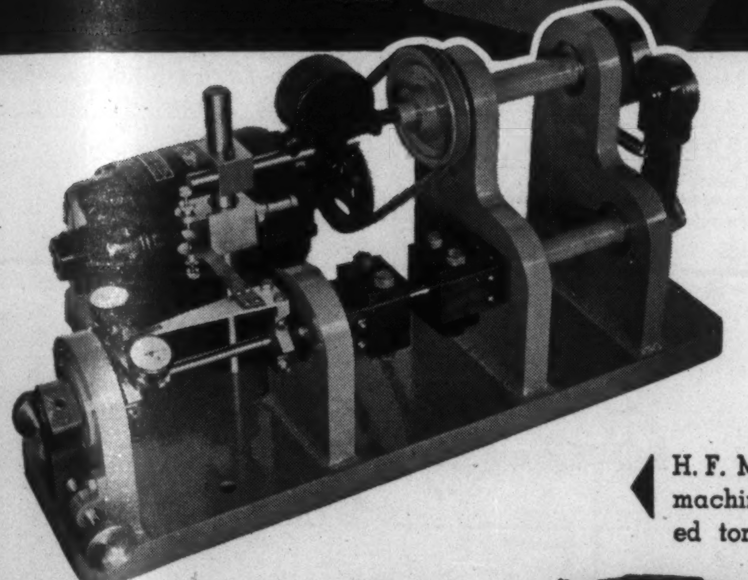
5 TYPES OF FATIGUE TESTING EQUIPMENT



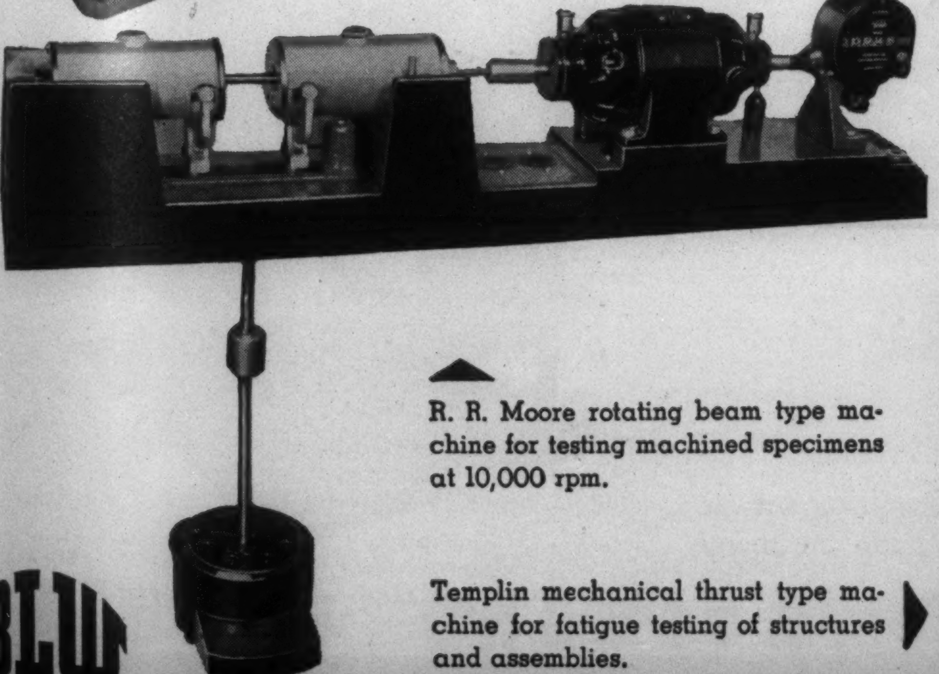
Bernhard Mechanical Oscillator for induced vibration testing of full size parts and structures.



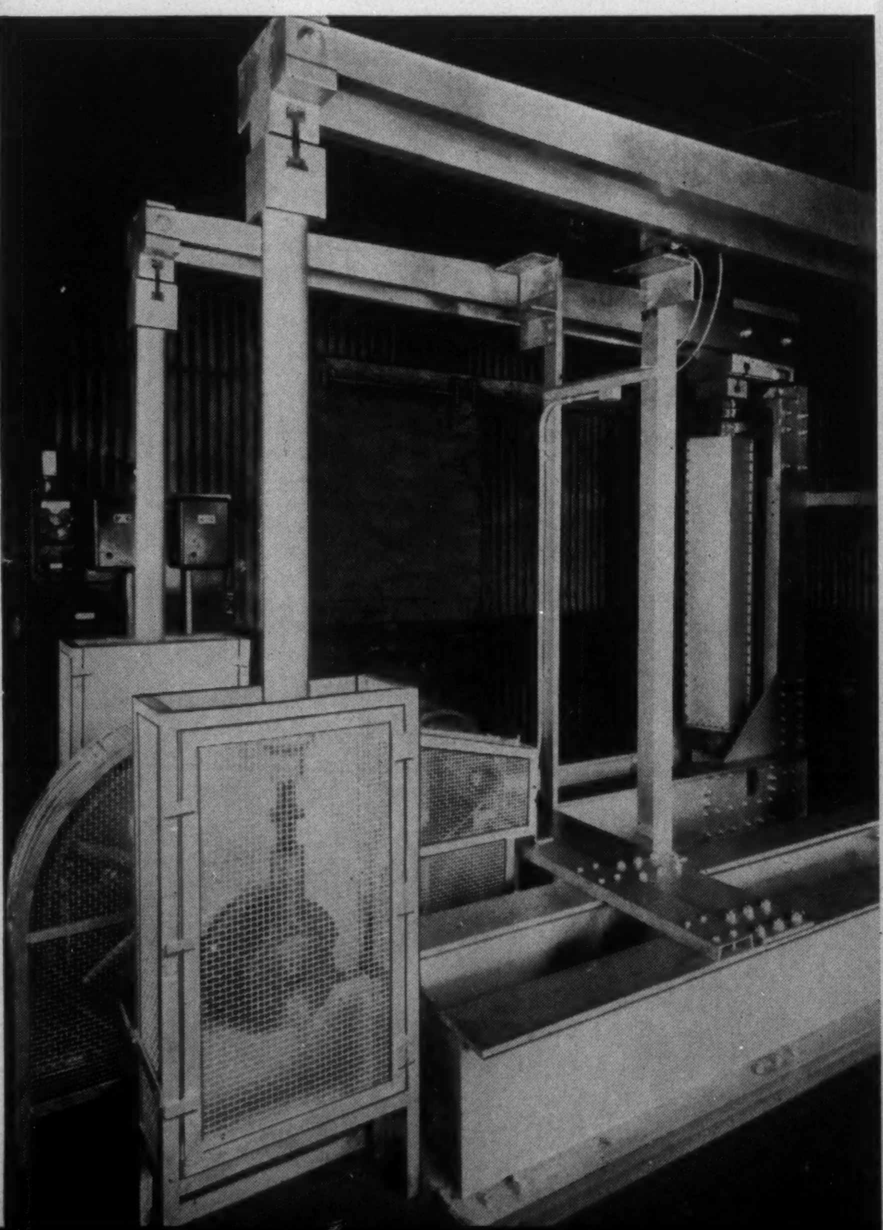
Baby Rayflex machine, electro-dynamic type, for testing unmachined specimens at resonant frequencies.



H. F. Moore fatigue machine for repeated torsion testing.



R. R. Moore rotating beam type machine for testing machined specimens at 10,000 rpm.



Templin mechanical thrust type machine for fatigue testing of structures and assemblies.

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the cathode. Currents as low as 0.005 milliamperes/cm.^{2} could be used.

The thicknesses of cuprous oxide films on copper and of silver sulphide films on silver as measured by the electrolytic method were found to be in good agreement with the film thicknesses determined by weight-gain of the specimen during oxidation. The film of cuprous oxide formed on reduced copper after 0.5 hr. exposure to the air was found to be 10-20 A.U. thick. This result is in agreement with measurements made by electron diffraction. When copper was abraded in the air or under a number of solvents, the thickness of the cuprous oxide film formed on the surface was about 30-70 A.U. thick.

The electrolytic method can be applied to determining the amount of two or more reducible substances in a tarnish film. This is done by observing the inflection points of the curves of cathode potential *vs.* time.

AB (4)

Specifications for Gray Iron

"FOREIGN STANDARD SPECIFICATIONS FOR GREY IRON." H. JUNGBLUTH. *Foundry Trade J.*, Vol. 61, Nov. 30, 1939, pp. 375-378. Translated from *Giesserei*. Survey.

The German standard specification distinguishes gray iron having guaranteed mechanical properties from other possible kinds of cast iron that are included in the category "Machinery castings with and without special specifications as to quality." One group of standard specifications other than the German specification proceeds on similar lines.

A second group of standard specifications incorporates the new idea that the specification relates only to castings having a definite maximum wall thickness, laid down in the specification. For instance, Norway solves the problem by first citing examples of the fields of application of the various standardized kinds of gray iron. It is then stated with regard to acid-proof and alkali-proof cast iron, heat-resistant cast iron, cast iron with special magnetic properties, etc., that special agreements outside the framework of the specification are to be made, and that all castings having a wall thickness exceeding 2 in. are to be excluded from the specification. The testing procedure in that case is left to special agreements between the customer and foundry.

The same principles are also indicated in the British and U. S. standard specifications. Great Britain has 2 standard specifications, one for "ordinary gray iron castings" and one for "high-duty gray iron castings." In addition, special agreements are again necessary between foundry and customer for many cast iron products.

An important question is whether a tensile test or a transverse test should be made. The advantage of the tensile test is that the test conditions are mostly clearly defined and the cross-section of the test bar is subjected to a uniform stress field. It has the disadvantage that it fails to provide any value for the deformation of the iron under stress, because the elastic deformations are too small to be measured without a mirror device, while plastic deformation in the form of an elongation practically never occurs.

The transverse test has the disadvantage of providing a composite field of stress under load and is hence not such a clearly defined test as the tensile test. [Complete information on the transverse properties of cast iron may be obtained when the method of step loading and unloading is employed.—A.I.K.] Norway and Italy lay more emphasis on the transverse test, and Czechoslovakia (*sic*) considers the tensile test to be more important, while the remaining countries treat both tests as equal.

AIK (4)

Specifying and Testing Sheet

"THE SPECIFICATION OF SHEET FOR DEEP DRAWING AND PRESSING." J. D. JEVONS. *Sheet Metal Ind.*, Vol. 13, Nov. 1939, pp. 1363-1367; Dec. 1939, pp. 1462, 1467-1468, 1472. Practical.

The properties generally specified in ordering sheet metal include grade, chemical composition, method of manufacture, grain size, microstructure, hardness, directionality, tensile values, cupping and drawing test values, bend test figures, surface condition and dimensional tolerance.

Impurities and elements that do not affect deep drawing should not be rigidly limited in the composition specification. It should always be remembered that only average values are given, whereas segregation may disqualify metal having satisfactory *average* chemical composition. As to grain size, the maximum variation for both inner and outer ends of coiled strip should be given; also, consideration should be given to the fact that regularity of grain size is almost as important as average grain size.

For hardness specifications Rockwell B is popular, but Vickers Pyramid Numerals with a load related to the sheet thickness are more reliable. Hardness itself has no relation to deep drawing properties, but

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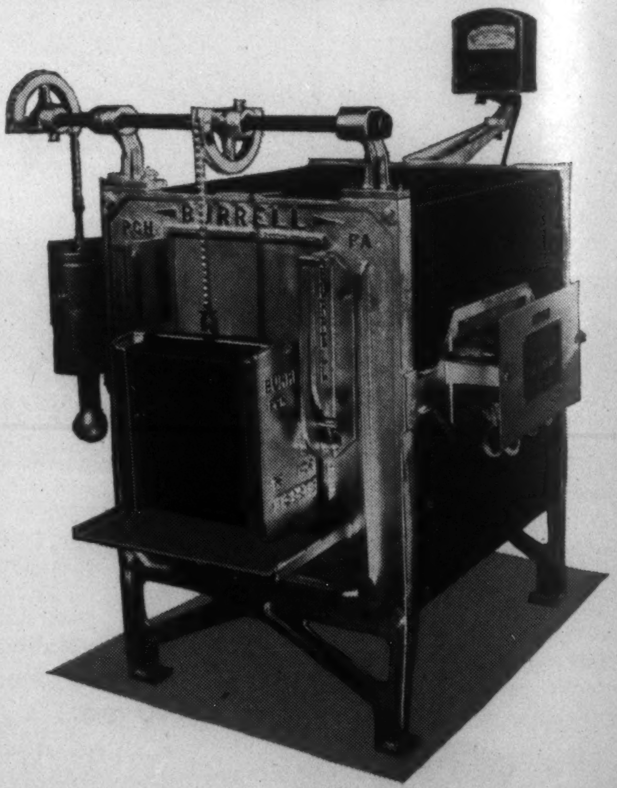
The heating chamber measures 4"x4"x13¼" deep. The floor is a removable, refractory plate with moulded sides to prevent spillage from reaching the insulation. Overall outside dimensions of the furnace are 26" wide x 30" high x 24" long.

The heating elements are designed to give long life but when it is necessary to replace them this operation can be done in five minutes without cooling the furnace.

Other standard models include muffle types—combustion tube types—and pit types. More information on request.



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RADIUM

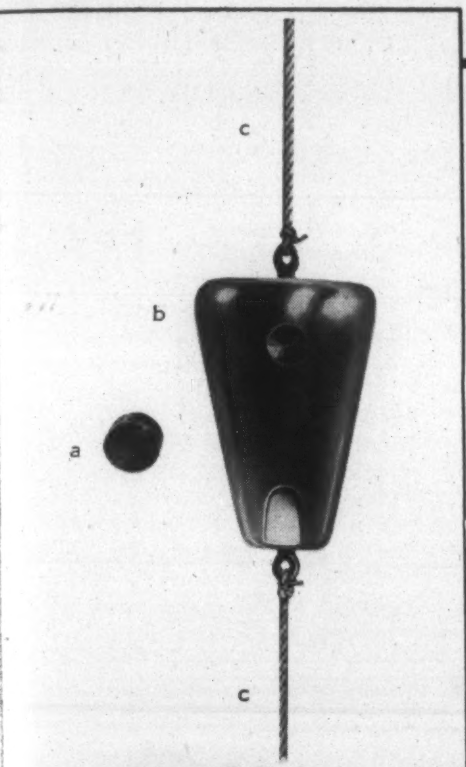

FIGURE 1

(actual size)

★

APPARATUS
USED IN
INDUSTRIAL RADIOGRAPHY

★

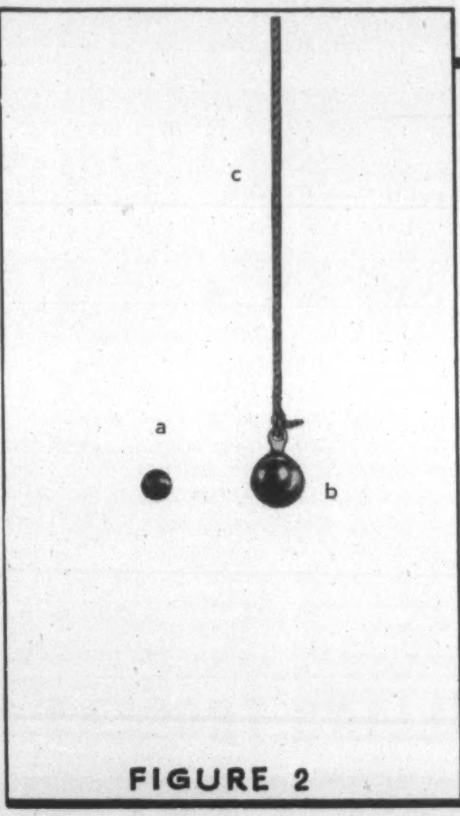

FIGURE 2

(actual size)

THE apparatus necessary for Radium Radiography is very simple. The small radium capsule (a) when placed in cartridge (b) is supported rigidly by string (c) in front of the specimen to be inspected. Films in light-tight holders are fastened to the back of the specimen to be radiographed. The rays passing through the specimen cause a shadowgraph to appear upon the film.

Capsule (a) shown in Fig. 1 contains from 100 to 500 milligrams of radium. Sphere (a) in Fig. 2 contains 25 milligrams of radium.

Radium offers many advantages namely its portability, ease of application and manipulation in the examination of castings, forgings, molds, weldings, and assemblies.

Radium reveals the entire inner structure of a specimen. Use radium when in doubt and be sure of the specimen.

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the uniformity in hardness values does give an indication of uniformity of other properties. While directionality is seldom specified, it should be, since it determines the evenness of flow in deep drawing and pressing. It can be measured by the tear-length test, by tensile tests in stated directions, or by the amount of anisotropy in X-ray photographs—the latter method is hardly feasible today.

Tensile tests are, of course, of primary importance. The proportional limit is useful only when sheet is purchased in annealed or normalized condition. Per cent elongation specifications should include the gage length and specimen thickness. Owing to the usefulness of full stress-strain curves, these may be included in future specifications.

Wedge drawing tests are useful but have not gained enough acceptance to be included in specifications. Cupping tests indicate drawability, average grain size and uniformity. Standards for average grain size as determined by the appearance of the dome are suggested. Specifications would then call for a cup of a certain dome surface on sheet of specific thickness. The "practical" drawing tests are excellent in theory but actually probably have all the disadvantages of the standard cupping tests, such as the Erichsen test. Tear length tests are valuable to determine directionality.

Bend test values are specified in older specifications but have little significance. Surface smoothness is important, but difficult to standardize. The surface condition (*i.e.*, the freedom from oxidation) must sometimes be covered in specification. Dimensional tolerances are easiest to specify, but should not be more exacting than necessary.

In general, "specification of certain properties is usually of value only when several are included and considered in relation to one another and also in the light of past experience." JZB (4)

Magnetic Tests for Age-Hardening

THE KINETICS OF PRECIPITATION PROCESSES AS SHOWN IN MAGNETIC MEASUREMENTS ("Die Kinetik der Ausscheidungsvorgänge auf Grund magnetischer Messungen") H. AUER. *Z. Elektrochem.*, Vol. 45, Aug. 1939, pp. 608-615. Research.

In the aluminum-copper system the homogeneous solid solution shows a radically different magnetic susceptibility *vs.* temperature curve from that of the heterogeneous alloy (consisting of diluted solid solution and precipitated $CuAl_2$ phase). The period of mere lattice-enrichment (during which up to the present time no new phase could be defined by any physical method), preceding the precipitation, can be followed quantitatively by accurately measurable changes in susceptibility. Considerable progress in the interpretation of the kinetics involved was made possible by the "retrogression" process (*Rückbildungsverfahren*).

This consists of a method of heat treatment by which the thermal stability of the different states can be determined; the velocity and the amount by which (with changing temperature) part of the change in state can be reversed again, are measured. For example: aluminum + 5% copper changes its susceptibility at room temperature along a slightly inclined logarithmic straight line, but from 200° C. on, it changes along a steeper line (increased rate of change). If the change is observed at room temperature for a certain period and the temperature is then suddenly raised to 200° C. the expected increased velocity of change in susceptibility does not occur immediately; the susceptibility goes back to its original value and only after this reversal does the change proceed according to the higher speed corresponding to the elevated temperature.

In other words, the state produced by room temperature aging is completely changed back to that of the quenched alloy before the change corresponding to the elevated temperature becomes noticeable. The retrogression is not in all cases complete. It depends on the time elapsing until the temperature is raised; on the temperature at which the retrogression is produced (e.g. 200° C.), and on the temperature at which the first change took place (e.g. 20° C.). If, after aging at 100° C., the temperature is raised to 220° C. a complete reversal takes place only after a certain original aging period—approximately 1 hr. Beyond this time the reversal is not complete; the reversed amount is constant regardless of the time elapsed (*i.e.* regardless of the amount of transformation that took place during the original aging). Only after raising this temperature to 240° C. can this state, too, be abolished.

If, on the other hand, the reversing temperature is chosen below 200° C. the reversal is incomplete even after a shorter initial aging treatment than the 1-hr. period mentioned above. Starting with an original soak of 50 hrs. at 150° C., the temperature was raised to various points between 150° C. and 300° C. That part of the original transformation that withstood the second heating without reversing was recorded. Thus a curve is plotted which shows 3 distinct zones: (a) up to 210°, (b) up to 250°, and (c)

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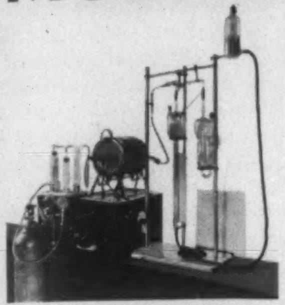

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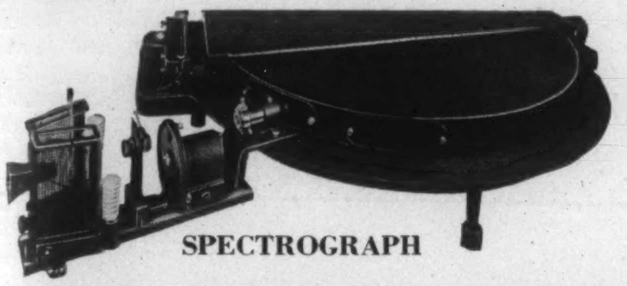

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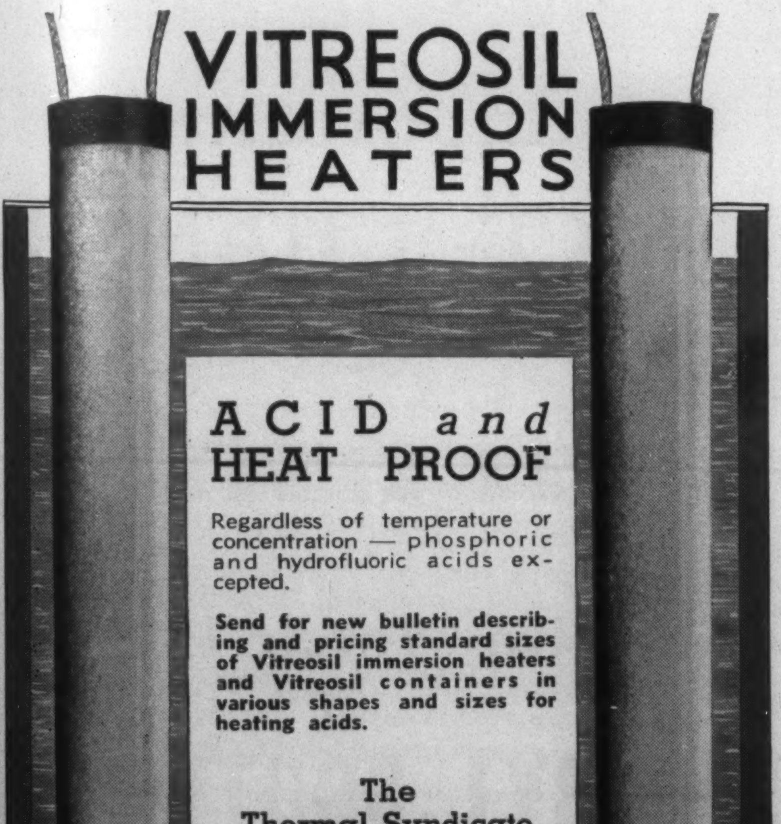

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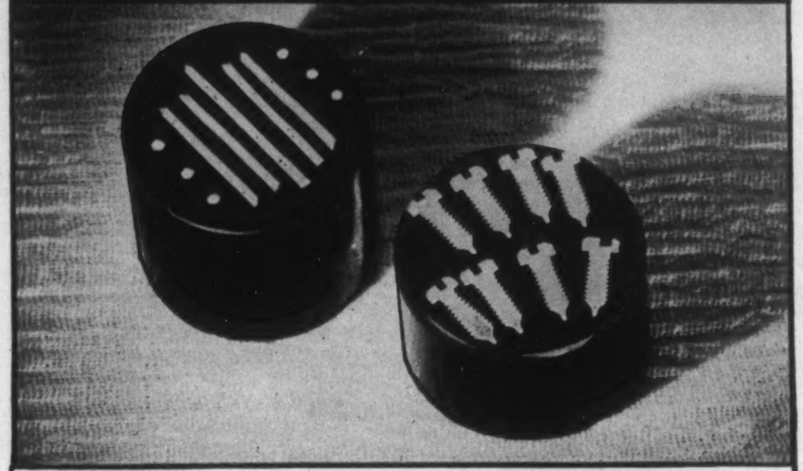

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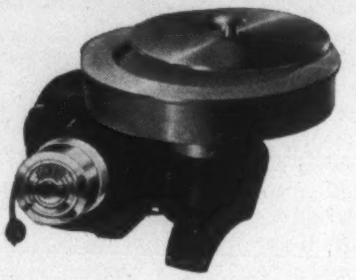

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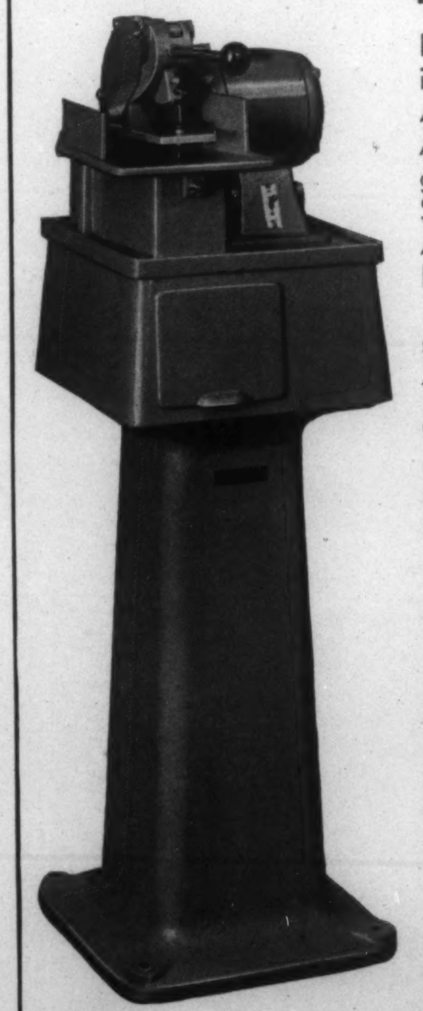

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a zone that can no longer be reversed at higher temperature (identified as heterogeneous precipitation of $CuAl_2$).

The velocity of retrogression rises at first in the (a) range, drops rapidly at 215° C. and then increases again up to 250° C. where the reversibility disappears. The precipitation process can be analyzed for these 3 ranges: For an initial aging temperature of 15° C. only (a) exists. This state is considered, therefore, solely responsible for the so-called cold-aging effect. At 100° C. (a) forms at first; after about 5 hrs. its amount stays constant and (b) starts; (b) is not formed by consuming (a).

It is concluded from this phenomenon that these conditions are not preparatory intermediate stages which transform gradually one into another until precipitation occurs; they are instead separate states that can exist side by side and which can be destroyed only indirectly by equilibrium changes. At 150° C. after 20 hrs. all three states exist; at 215° C. right from the start only (b) forms and after about an hour (c) appears. The curves of logarithm of velocity of transformation or retrogression against the reciprocal of time represent straight lines regardless of whether only one state or more than one exist at the same time. This is considered another evidence that the 3 stages do not merge into one another but are independent.

Activation energies are computed from the slope of the straight curves. The rate of quenching shows a strong influence and it is possible to isolate the different stages of aging. The quantities of heat developed were measured and found to be: 0.05 cal./g. as formation heat for (a) at 100° C.; 0.2 cal./g. as formation heat for (b) at 200° C. and 3 cal./g. as formation heat for (c) at 300° C. The different stages can be recognized by other properties (electrical resistance, a specific heat, hardness, etc.) but are not so well defined as in the case of magnetic susceptibility. It is possible to analyze by this method the technically important age-hardening alloys for the different stages of aging. RPS (4)

Machinability Testing

TESTING THE MACHINABILITY OF VARIOUS METALS BY MEANS OF THE "DOUBLE-STEEL METHOD" ("Zerspanbarkeitsprüfung verschiedener Metalle mit dem Zweistahlverfahren") F. SCHICHA. *Techn. Zentralbl. prakt. Metallbearbeitung*, Vol. 49, Oct. 1939, pp. 693-698; Nov. 1939, pp. 740-743. Comprehensive review and original research.

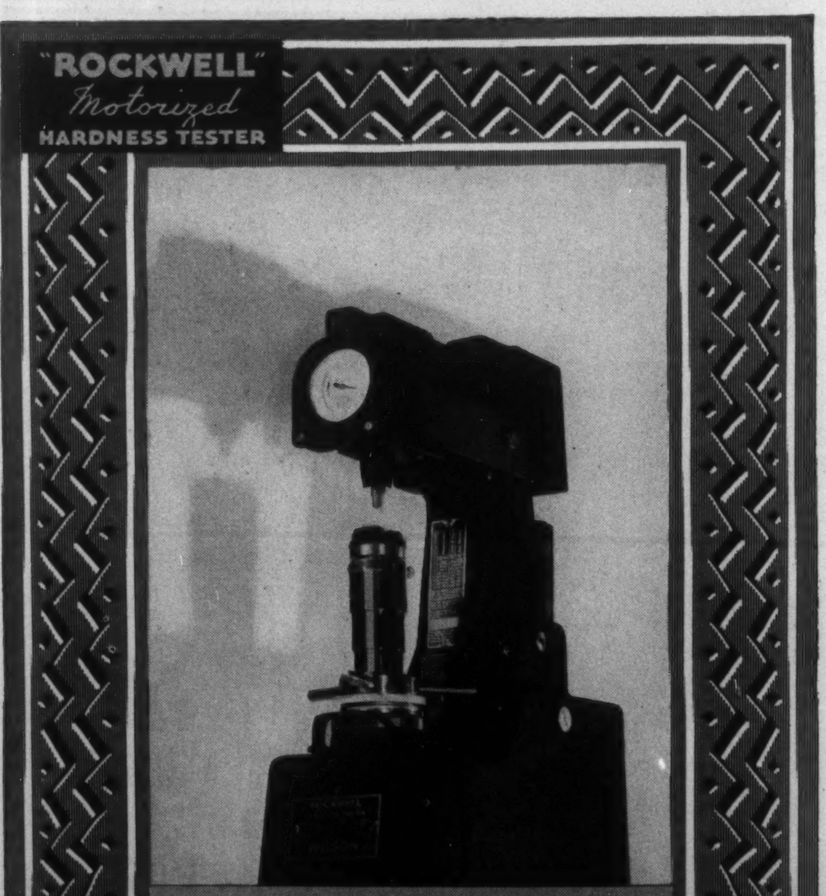
Using the method of Gottwein & Reichel (see *Metals and Alloys*, Vol. 9, Dec. 1938, p. MA 706L/1), the author studied the machinability of steel, cast iron and light metals, and applied the testing method, originally designed for turning, to fine boring, drilling and milling. The procedure is to machine the metal simultaneously with 2 cutting tools of different composition, which form the legs of a thermocouple. The temperature at the cutting point can thus be measured with a millivoltmeter and serves as a measure of machinability.

Eight steels, 10 standard light metal alloys, and 5 cast irons (the composition of which are not given) were machined in the lathe at three different feeds and at speeds varying between 100 and 250 ft./min. The experimental results are graphically presented. The order of merit of the various metals is different at different feeds. Increasing the working speed does not raise the temperature to the same extent with the different materials. These observations hold for all the steels and aluminum alloys tested.

A modification of the original "double-steel method" was worked out for the fine boring tests. The speed/e.m.f. curves become straight lines on a double-log scale, and those materials that are difficult to machine are conspicuous in the diagrams. The use of 2 different drills (high speed and ordinary cutting steel) offered some difficulties in the drilling tests, but these were overcome by using gasoline lubrication. This was said not to affect the e.m.f. generated as the liquid "does not penetrate to the cutting edge." Short-circuiting by the drilling chips does not interfere, and the testing method is concluded to be applicable to drilling.

As the tool is only intermittently in contact with the work in milling, and since the working temperatures are much lower—as is evident from the longer tool life in milling—the original "double-steel method" required modification. All 3 types of materials were tested in milling. In the case of steel, the feed markedly affects the e.m.f. For instance, doubling the chip size entailed a doubling of the e.m.f.—or in other words, of the temperature—while doubling the milling speed raised the temperature only 20-50%.

The experimental results are summarized in a very useful table showing the order of merit of all materials tested in turning, fine boring, drilling and milling at different speeds and feeds. Machining by various methods yielded different orders of merit. Certain metals are well suited for drilling but are difficult to mill. No correlation of Brinell hardnesses to machinability could be found. The reproducibility of the testing results in boring, drilling and milling indicates the usefulness of the testing method. Also, unlike many former testing methods, the "double-steel method" is applicable to non-ferrous (light metal) alloys. EF (4)



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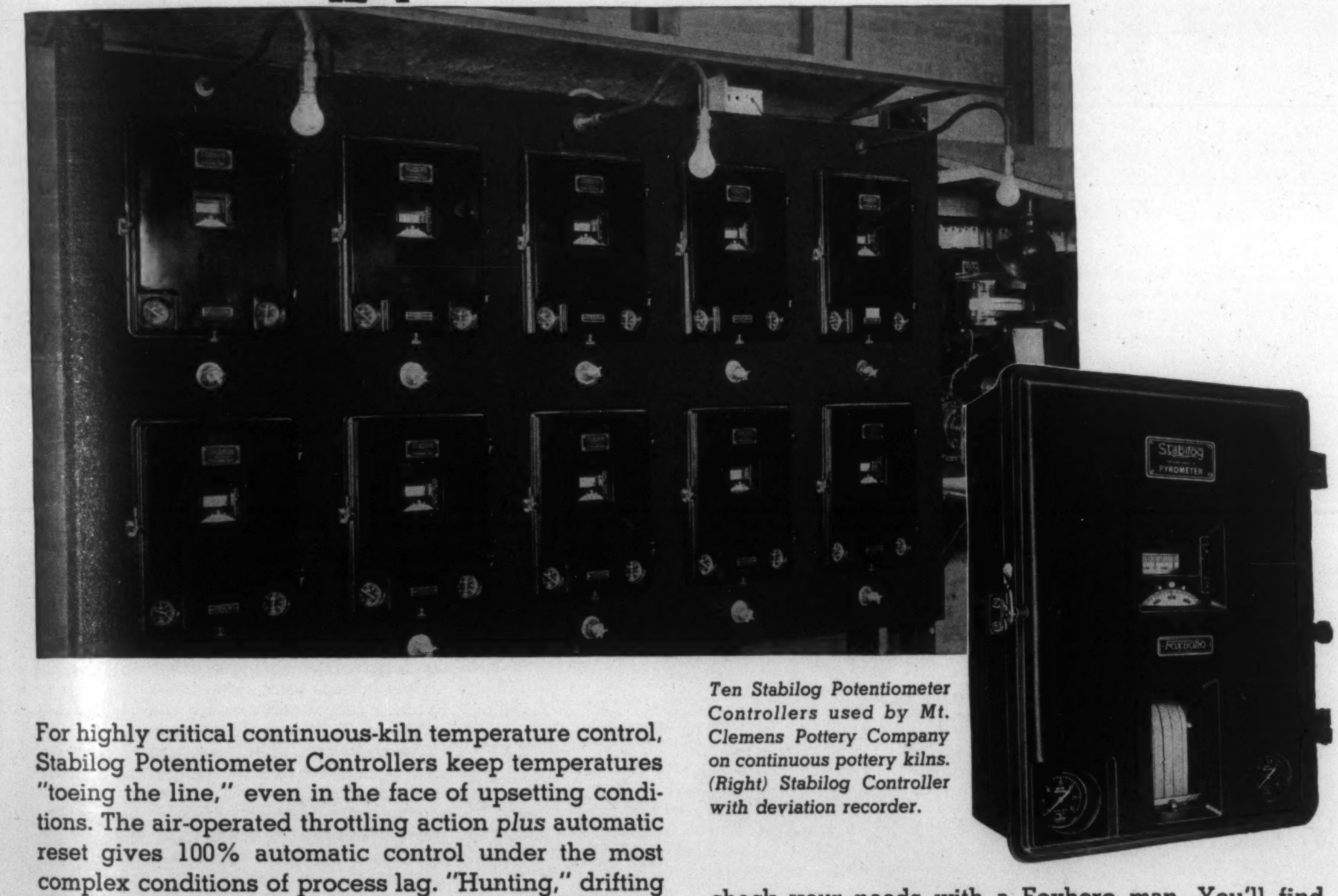

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Specifications for Electroplates

"A Suggested Basis for Specifications of Electroplated Coatings of Nickel and Chromium." A. W. Hothersall, *J. Electrodepositors' Tech. Soc.*, Vol. 15, 1939, pp. 195-204.

The British Non-ferrous Metals Research Association has suggested specifications to assist their members in framing their own detailed specifications. These specifications cover the requirements for decorative or protective electrodeposited coatings of nickel and chromium on steel or on copper alloys containing more than 50% copper.

Quality	Service Conditions	Minimum Thickness of Undercoating (in.)	
		On Brass (Nickel)	On Steel (Nickel or Nickel-Copper-Nickel or Bronze-Nickel)
A	Mild	0.0002	0.0004
AA	General	0.0004	0.0008
AAA	Severe	0.0006	0.0008

The coatings must be free from imperfections such as blisters, pits, cracks, etc. Three qualities of complete coating are specified. They differ with respect to the minimum thickness of nickel undercoating to be used, as is indicated in the table. The average thickness of coating would usually be two or more times the minimum thickness.

The porosity of AAA quality plating, as determined by the ferricyanide test should be less than 6 pores/ft.^{2} Chromium should always be applied over a nickel undercoating and should have an average thickness of 0.00002 in. for qualities A and AA, and a thickness of 0.00004 in. for the AAA quality.

The BNF jet test is suggested as a minimum-thickness test for nickel coatings. A sample fails if the coating falls below the required minimum thickness at 2 points more than 0.5 in. apart. The thickness test for chromium consists in measuring the time required for a reagent (20 g. of Sb_2O_3 in 1 liter of HCl of sp. gr. 1.16) to dissolve the chromium coating. AB (4)

New (Magnetic) Carbon Analyzer

"A New Instrument for the Magnetic Determination of Carbon in a Steel Bath." H. K. Work & H. T. Clark (Jones & Laughlin Steel Co.) *Metals Tech.*, Vol. 6, Dec. 1939, 11 pp.; *Steel*, Vol. 106, Feb. 5, 1940, pp. 62, 64. Descriptive.

For a number of years an instrument of Swedish manufacture called the Carbometer has been used with considerable success in American steel mills for determining the carbon content of steel during the steelmaking process. In determining carbon contents with the aid of this instrument, a spoonful of molten metal is taken from the furnace, a known amount of aluminum wire fed into the steel in the spoon, and the metal cast into a special mold. After cooling in a given manner, the sample is placed in a Carbometer and the carbon content estimated in a very few seconds. In principle, the Carbometer resembles a permeameter except that the change in flux in the specimen is produced by a mechanical arrangement involving the use of a permanent magnet and rotating soft-steel bars.

A newly developed instrument of the permeameter type is described, and the data shown in the paper indicate that the new machine, named the Carbanalyzer, gives quite accurate estimates of carbon contents. The Carbanalyzer may be classed as a special form of permeameter, since it measures the change in flux in a bar produced by a known change in magnetizing force. The change in the magnetizing force (ΔH) in this case is equal to 2H, and the change in flux ($\Delta \phi$) is equal to 2ϕ, because the current in the magnetizing coil is reversed. Thus, the permeability of the material, for the known value of H and cross-sectional area of the bar, can be calculated by the ordinary magnetic equations. In the present instrument absolute values are of no interest, since the galvanometer deflections observed are directly convertible to carbon contents through calibration.

The new instrument is fast and convenient, and relatively inexpensive, and is more rugged than the Carbometer. The temperature changes cause the current to change slightly, but the instrument is in correct calibration as soon as the current has been set at the correct value. The Carbanalyzer has been used steadily for testing the Jones and Laughlin Company's commercial open-hearth heats for the past 18 months. JLG (4)

5 General

Articles pertinent to more than one of the previous sections.

Gases and Metals

A Composite

Problems involving both gases and metals are far more numerous than is commonly supposed—for the field includes not only the gassing of molten metals and the mechanical effect of dissolved, adsorbed or entrapped gases in solid metals, but chemical reactions between metals and gases, the effects of metal-gas compounds in metals, diffusion of gases through metals, and other subjects of individual interest to melter, welder, heat treater, electroplater, pickler, and those who have to work and to use metals in gases (and who doesn't?) and under high or vacuum pressures, high temperatures, unusual stress conditions, and so on. These are all discussed in several recent articles, digested herewith.

Gas holes in cast iron are studied by W. Y. Buchanan ("A Preliminary Study of Gases in Cast Iron," *Foundry Trade J.*, Vol. 61, Dec. 21, 1939, pp. 423-424; Dec. 28, 1939, pp. 443-446). The gases from molten cast iron were collected under a cast iron bell. The bell is bored and tapped without using oil and then the inside is sandblasted carefully, using a new bell for each experiment. The volume of gas evolved is important, since it may be assumed that a small volume would tend to produce a smaller gas-hole content than would a large volume.

Systematic tests on the use of powdered scale show that very heavy scale additions can be used without causing any reduction of the total carbon, and that this reduction of carbon does not take place in the presence of even low silicon. Mill scale gave the best gas reduction; a rapid reaction took place, which was complete in a very short time after the ladle was filled, and appeared to cause no decrease in temperature. The treatment of cast iron with scale appears to reduce the sulphur content slightly.

The total volume of gas is reduced by scale treatment to about half that in the untreated sample. The volume of gas found in iron treated with soda ash is greater than in the untreated metal. The addition of scale to soda ash appears to effect the desired degasification with a reduction of the heat loss, and probably more efficient purification.

In general, the use of light scrap, which causes gassy metal in the ordinary cupola, makes no difference when using the balanced-blast cupola. Moisture is the cause of most gas formation in cast iron. In high test irons the presence of gas is more serious than in low-grade irons, owing to the tendency to low fluidity in these irons.

A comprehensive discussion of gases in steel is given by G. T. Motok of Republic Steel Corp. ("Gas Content *vs.* Steel Behavior," *Iron Age*, Vol. 144, Nov. 30, 1939, pp. 25-28; Dec. 7, 1939, pp. 40-43). Much information on variation in characteristics of supposedly identical lots of steel has been given by the company's vacuum extraction technique for gas analysis. The presence of oxygen is believed to affect the solubility of carbon in austenite and ferrite and thereby affects the structure of iron and steel. Variations in such properties as strength, ductility, impact resistance, elastic limit, etc., have been attributed to oxygen. Nitrogen has a great effect on the hardness, ductility, tensile strength, elastic limit and magnetic properties of steel. Nitrogen seems to have 4 times the effect of phosphorus on the mechanical properties of steel, and this effect may be further intensified by the presence of carbon or alloying elements. The brittleness of freshly-deposited electrolytic iron and the brittleness following pickling have been attributed to hydrogen. Data are tabulated on the gas content (weight %) of steels made by various processes.

In the vacuum extraction method of determining gases, an alloy of steel and tin is heated in a graphite crucible in a very high vacuum. Carbon from the graphite enters the molten steel and reacts on oxides individually. Nitrogen, hydrogen and oxides of carbon are evolved, collected and analyzed by standard gas analysis methods. Iron oxides are reduced first, then at high temperatures manganese oxides, silicates and aluminum oxides. Thus, the "gas content" as revealed by this method is the amount of elemental and of combined (as oxides, silicates, etc.) gases present in the steel.

Some interesting cases of the use of gas analysis to solve practical problems are cited. Of two steels used for making dies, one could be hardened without difficulty to Rockwell C 70. The other steel would occasionally reach the required hardness but normally would not go above Rockwell C 66, and difficulty was encountered with soft spots. The chemical composition of both steels lay in the following range: 1.25-1.30% C, 0.25-0.35 Mn, 0.025 P, 0.025 S, 0.15-0.25 Si and 0.05-0.15 Cr. By vacuum extraction of gases it was found that the steel that hardened without difficulty contained a smaller amount of oxides than did the other. It was found that during steelmaking the poorer steel was oxidized more than the other, and on the addition of deoxidizers the poorer steel retained more oxides. The final cleanliness of steel is thus not independent of conditions prior to refining. Although there was no difference in hydrogen and nitrogen content of either steel, most of the hydrogen was given off at the highest extraction temperature, and most of the nitrides were dissociated at lower temperatures.

Again, tests run on two samples of silicon-killed steel showed the sample that gave a poor nick-break test to contain twice as much hydrogen and nitrogen as the other, which, although high in oxygen (as MnO), had good mechanical properties. In still another case, plates of propeller stock made from electric furnace steel (S.A.E. 6130) reacted differently when subjected to the flame-torch test to determine weldability. Vacuum-fusion tests showed that the satisfactory steel had lower oxygen, nitrogen, and alumina. With two spring steels of similar composition and treated in the same manner, greater amounts of gases and oxides in one sample accounted for a considerable difference in behavior when tested to destruction on a 500-ton press, although routine chemical and physical tests did not show any difference.

Four samples of stainless steels that resisted pitting to different degrees were tested. Three samples had the regular mill carbide-solution treatment. The fourth sample was slightly cold-rolled. From vacuum fusion extraction, it was noted that the total oxygen was higher in the two steels that offered greater resistance to pitting. It is unlikely that high total oxygen would prevent pit corrosion, but it is possible that the oxygen occurring as Cr_2O_3 may be a factor. Oxides and nitrides of chromium, by forming an oxide-nitride film on the grain surface, may diminish the susceptibility to corrosion of this type.

As Motok indicates, brittle welds in steel are often blamed, and correctly so, on too-high oxide and nitride contents. Another welding defect sometimes attributed to oxygen and nitrogen in steel is "burning"—the frothy or burned appearance of the underside of a weld. However, T. SWINDEN & H. SUTTON ("Burning during Welding of Mild Steel Sheet," *Trans. Inst. Welding, London*, Vol. 2, Oct. 1939, pp. 187-189) made analyses and found that the tendency to burn is not associated with the content of oxygen, hydrogen or nitrogen in the steel, but is unfavorably influenced by residual metal and metalloid content—except for silicon content, which is beneficial.

In all gas-metal phenomena diffusion is almost always a factor, though often unrecognized. J. H. SIMONS & W. R. HAM ("Diffusion of Gases Through Metals from a Chemical Point of View," *J. Chem. Phys.* Vol. 7, Oct. 1939, pp. 899-902) consider this problem from the standpoint of metal-gas compounds formed between the diffusing gas and the metal, and succeed in correlating the magnitude of the exponent of the gas pressure in the diffusion isotherms with the chemical reactions within the metal. R. M. BARRER ("The Permeability of Metal Membranes to Diatomic Gas," *Phil. Mag.*, Vol. 2, Sept. 1939, pp. 353-358), states that gas flow through metals is accompanied by dissociation of the diffusing molecule, so that the rate is proportional to the square root of the pressure. This holds for the diffusion of hydrogen through palladium, platinum, nickel, iron, and aluminum; of sulphur dioxide through copper; of nitrogen through iron and molybdenum; of oxygen through silver; and of carbon monoxide through iron and nickel.

If this be true, then gas atoms externally produced should also diffuse rapidly in metals even *against* a high pressure from an atmosphere of molecules of the same gas. And this is exactly what happens, according to J. H. DE BOER & J. D. FAST ("Die Diffusion von Wasserstoff durch Eisen bei Zimmertemperatur," *Rec. Trav. Chim.*, Vol. 58, Sept./Oct. 1939, pp. 984-993) who sought information on one of the above cases—the diffusion of hydrogen through iron at room temperature. They found that hydrogen atoms formed in hydrogen gas by means of an incandescent tungsten coil penetrate readily into iron plates at room temperature. A vessel having an iron wall and filled with hydrogen can be evacuated by producing hydrogen atoms in this manner within the vessel—the hydrogen diffuses from the inside out, for only the atoms pass through the iron. The hydrogen accumulates on the outer side and diffusion takes place against an atmosphere of hydrogen at any pressure. Proof is also offered that hydrogen atoms formed by a chemical reaction between iron and a solution may enter the iron, whereas the hydrogen ions contained in a non-reacting solution are unable to do so.

W. R. HAM ("Diffusion of Hydrogen Through Oxygen-Free Copper," *J. Chem. Phys.*, Vol. 7, Oct. 1939, pp. 903-907) finds that the removal of all traces of oxygen from copper has the same effect on low-temperature diffusion isotherms as the removal of all carbon from iron and nickel—these isotherms become perfectly normal, the rate varying exactly as the square root of the pressure.

Involving diffusion, as well as chemical reactions between gas and metal at the surface of the latter, are the many familiar cases of base metal oxidation. One of these—the oxidation of beryllium at high temperatures—is investigated and compared with the oxidation of nickel by H. M. TEREM ("Etude Comparative de l'Oxydation du Glucinium et du Nickel à Haute Temperature," *Bull. Soc. Chim.*, Vol. 5, Apr. 1939, pp. 664-672). At 1000° C. beryllium reaches a given stage of oxidation in 1/100th of the time required by nickel.

Noble metal oxidation, however, is a less familiar story—in fact, it is popularly believed that the noble metals do not oxidize. Surface oxides on noble metals are discussed by H. SCHUTZA ("Oberflächenoxyde auf Edelmetallen," *Umschau*, Vol. 43, Dec. 1939, pp. 1061-1062). The surface oxidation protects the metal underneath from further oxidation if the surface film is coherent. Passivation of freshly etched gold in a suitable electrolyte takes longer than of gold that has previously been exposed to the atmosphere. Finely powdered gold absorbs oxygen in considerable quantities which cannot be removed in vacuum, and the amount absorbed increases with rising temperature. At elevated temperature, progressive oxidation often takes place. Some oxides, that of gold *e.g.*, are not stable, and it is impossible to maintain a heavy oxide layer at elevated temperatures at atmospheric pressure. X (5)

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Steels

MODERN STEELS (Manufacture, Inspection, Treatment, Uses). *Edited by E. E. Thum. Published by American Society for Metals, Cleveland, 1939. Cloth, 6¼ x 9¼ in., 374 pages. Price $3.50.*

This is a series of educational lectures given under the auspices of the Pittsburgh chapter of the A.S.M. by M. W. Lightner, G. R. Fitterer, L. H. Allison, A. W. Demmler and J. P. Gill. The chapters deal with raw materials, steel-making processes, pouring, hot working, inspection and testing, metallography (equilibrium structures, slowly cooled steels, quenched and tempered steels), heat treatment (softening and hardening, and equipment), alloy steels, stainless steels and tool steels.

The subtitles and the chapter headings cover a lot of ground, and one can justly expect to get only an inkling from a few lectures on such wide fields. The first five chapters are what would be expected, somewhat informative, but sketchy and superficial. The latter part, especially those on structure and heat treatment, boil down a lot of information into concentrated but digestible form.

Everything in the book is, naturally, available elsewhere in fuller form. Nevertheless, the book has a purpose, which it serves well. One grasps a subject better if he reviews it from time to time by the use of a text written by someone with a different point of view from the one he first studied. Different authors say the same thing in different ways and their messages register differently. By reading several presentations, the vital truths that fail to register from one author will register from another. No one will get a very good grasp of all the topics treated by studying this book alone, but along with others (which are listed for further study at the end of each chapter) the home student can get a better grasp than from any single book. For the beginner starting such a study, or for an experienced metallurgical engineer who wants to review the topics on a fairly up to date basis, this volume will serve nicely.—H. W. GILLETT.

Strategic Minerals

STRATEGIC MINERAL SUPPLIES. *By G. A. Roush. Published by McGraw-Hill Book Co., New York, 1939. Cloth, 9¼ x 6½ in., 485 pages. Price $5.00.*

Timely in its appearance and thorough in its treatment, this book will inform many as to the extent to which the United States is dependent, particularly in war time, on foreign sources for important metals and minerals. The author is not only editor of *The Mineral Industry* but is also a major in the staff specialist reserve of the U. S. Army. These activities have put him in close touch with the subject he discusses. The volume is of value to many metallurgical and mining engineers.

After 2 chapters on Strategic and Critical Minerals, and a General Survey, the following materials are taken up: Manganese, Nickel, Chromium, Tungsten, Tin, Aluminum, Antimony, Mercury, Platinum, Mica, Iodine and Nitrogen. Closing chapters deal with Domestic Self-Sufficiency, Strategic Mineral Supplies in Foreign Countries, and Commercial Interests vs. Political Interests. The chapter on manganese is of special importance and is ably and fairly treated.

There is a large number of statistical tables on world production, available supplies, imports of the dozen or more materials discussed. Some 40 charts add value to the interpretation of the discussions.

Many will be interested in the chapter on Strategic Mineral Supplies in Foreign Countries and in the rather unique chart showing self-sufficiency ratings for strategic minerals in the leading countries—EDWIN F. CONE.

Analysis of Iron and Steel

DETECTION AND DETERMINATION OF FOREIGN ELEMENTS IN IRON AND STEEL (Nachweis und Bestimmung von Fremdelementen in Eisen und Stahl). Part *F II, Section 2 of "Gmelins Handbuch der anorganischen Chemie," 8th Ed., System No. 59. Iron. Published by Verlag Chemie, G.m.b.H., Berlin, 1939. Paper, 7x10¼ in., 388 pages. Price 27 RM.*

In this handbook, which has been revised and brought up to date, the method of presentation is excellent. Common elements, such as Al, Cr, Ni, and Cu, as well as the less common elements, Ce, Ta, etc., are thoroughly covered. A section is devoted to each element thereby facilitating use as a reference book.

A typical example of a section illustrates the method of presentation. The section on the detection and determination of titanium covers the following points: (1) Occurrence in Iron and Steel, (2) Detection, and (3) Determination. Under the last are found: (a) Influence and separation of interfering elements, (b) gravimetric methods of analysis, (c) colorimetric methods of analysis, (d) volumetric methods of analysis, and (e) potentiometric methods of analysis. Under each heading pertinent references are cited and abstracted, and in many cases complete working methods are given. A large part of the references are to the German literature, but they cover the field quite thoroughly and include modern advances.

Sections are also included on methods of analysis with special tools such as the polarograph and spectrograph. The book provides an excellent source of information on the analysis of iron and steel, and, despite its high cost, is recommended as a reference book for anyone dealing with a large variety of analytical problems in alloy steels.—A. E. PAVLISH.

Other New Books

PLATINUM—PRODUCTION OF THE PLATINUM METALS (Platin—Darstellung der Platinmetalle). Gmelins Handbuch der anorganischen Chemie, 8th Edition, System No. 68. Part A, Section 3. *Published by Verlag Chemie, Berlin, 1939. Cardboard, 7 x 10¼ in., 119 pages. Price 14.25 RM.* Describes the occurrence, extraction and refining of the platinum metals.

PLATINUM COMPOUNDS (Platin—Verbindungen bis Platin u. Wismut). Gmelins Handbuch der anorganischen Chemie, 8th Edition, System No. 68. Part C, Section 1. *Published by Verlag Chemie, Berlin, 1939. Cardboard, 7 x 10¼ in., 140 pages. Price 16.50 RM.* Covers the chemical and metallic compounds of platinum with the gaseous elements, sulphur, selenium, tellurium, carbon, boron, silicon, phosphorus and arsenic.

WELDING ENGINEER'S POCKET BOOK. *Published by Chemical Publishing Co., Inc., New York, 1939. Cloth, 4 x 6¼ in., 240 pages. Price $1.50.* An excellent little book, covering the practical fundamentals of all types of welding, of oxygen cutting, of brazing, and of weld-testing. Gives much attention to necessary differences in handling different metals.

A HANDBOOK OF BOILER MAKING. *By Kenneth Morrison. Published by Chemical Publishing Co., Inc., 1939. Cloth, 5 x 7½ in., 106 pages. Price $1.50.* A practical handbook for the sheet metal worker, giving fundamental principles used throughout the trade and the author's own practice.

Cast Metals

Cast Metals Handbook—1940 Edition. *Published by American Foundrymen's Assoc., Chicago, 1939. Cloth 6 x 9 in., 504 pages. Price $5.00 for non-members; $3.00 for members, or free on return of old edition.*

Information available since the first edition in 1935 has been included, such as that from recent symposia. The data in "Alloy Cast Irons," also published by the A. F. A. in 1939, have been boiled down for this handbook. Previously unpublished data are included in the section on cast steel, making that section quite the latest word on the subject, though the sub-section on oxidation and corrosion resistant castings probably falls several years short of representing present knowledge. The sections on design of castings and on testing are good and are written to inform and impress purchasing agents, and customer engineers as well as foundrymen. Cast steel, cast iron, malleable and pearlitic irons are covered quite adequately. Non-ferrous alloys are not given so much space, but the discussion is good and the information up to date.

Relatively few errors or omissions of vital facts appear on casual inspection. It seems odd, in view of the comment that cupola malleable encounters little trouble from galvanizing embrittlement, to find no discussion of this condition for regular malleable. In the table of properties of zinc-base die casting alloys, Charpy impact figures are given without explanation that they are not determined on the same bar as the Charpy figures for other alloys.

A.S.T.M., Federal, and other specifications for the various cast alloys are collected at the end of each section. This is very convenient. No metallurgical engineering bookshelf is complete without this handbook.—H. W. Gillett.

Popularized Steel History

Iron Brew. *By Stewart H. Holbrook. Published by Macmillan Co., New York, 1939. Cloth, 6 x 8½ in., 352 pages. Price $2.50.*

On page 3 we meet a Bessemer converter—"a roc's egg with one end cut off and gaping. . . . Into this caldron goes molten ore, 50,000 lbs. at a time."

This cheerful assumption that ore equals iron and the Sunday supplement phraseology—roc's egg, caldron, and the like, are dead give-aways. The book is written by an outsider, looking in, and by an outsider who is more interested in how he says a thing than in what he says. He must have looked up from his typewriter many times in self-congratulation after having written a striking sentence. So the reader is forewarned that the author is looking for the striking things, for something to phrase with a peculiar twist, and that his appraisal of what he records may or may not be correct.

The author was impressed that the men of ore and the men of steel were forceful individuals, so he deals more with the personalities of men than with their achievements, and if he can muckrake the pioneers a bit, he delights in doing it.

The vision, financial and engineering ability of Harvey, who built the Soo Canal are recognized less grudgingly than in the case of most of the other men featured in his "history." The "history" starts with the finding of Lake ores in 1844, carries the ore story on for a few chapters, devotes one chapter to ore boats, and then turns to steel.

Of Kelly, Capt. Bill Jones, Frick, Carnegie, Gary and others are cited the legends one has read in other places. The Homestead strike riots are reported. Bouquets are handed to Big Steel for dealing with the C.I.O. The author concludes that what lies ahead for steel is now less in the hands of the steel barons than of the technicians and the labor unions.

Even a psuedo-historian cannot fail to note the impact of technical changes. The author has not brought out very clearly the effects of technology, but has confined his attention pretty closely to the personalities of the men whose doings he chronicles.

The book is an interesting attempt to record events in terms of men, especially of the peculiarities of men. It would be better history had it been strung on the thread of technical and economic factors rather than on personalities, and, whether written for history or for entertainment, it would have been better reading had it been written in a less smart-alecky fashion. Dry-as-dust history is hard reading, and it is well that it be enlivened, but liveliness itself gets tiresome.—H. W. Gillett.

BETTER
PRODUCTS BECAUSE OF
BELLISLAVITE . . .

- BELLISLAVITE is more than a furnace, more than a heating medium. It is a complete heat treating process, with applications wherever metal must be heated cleanly, uniformly and economically.

BELLISLAVITE electric furnaces employing LAVITE as the heating medium are making noteworthy contributions to industrial progress and to better product quality. High speed tools do better machine work because they're hardened and tempered in BELLISLAVITE furnaces. Alloy wire for a thousand applications is more durable and uniform because it's annealed by this modern process.

Railroad, automotive and aircraft parts function more efficiently when brazed in Lavite furnaces. And a multitude of copper, brass, silver and aluminum products are better-made and more attractive by virtue of BELLISLAVITE annealing in their manufacture.

There's a logical place for Lavite in every metal-treating shop, whatever the job, whatever the product.

THE BELLIS HEAT TREATING CO.
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CURRENT news

Chicago Convention and Exhibit of A.F.A.

Enthusiasm, following the announcement that the 44th Annual A.F.A. Convention and Foundry and Allied Industries Show would be staged in Chicago, May 4-10, led those connected with the staging of those events to believe that the 1940 affair would be best and largest held in recent years and possibly in the history of the Association.

That these beliefs were correct is shown by the fact that in a recent release, C. E. Hoyt, manager of exhibits, stated that "the 1940 Foundry and Allied Industries Show, May 4-10, as indicated by exhibition space requests, will be the most extensive and interesting ever staged." This interest is due undoubtedly to the central location of Chicago as a foundry center, to developments made in foundry equipment since the last show was held in 1938, to better business conditions, and to the unusual exhibit facilities of the International Amphitheatre. where the exhibit will be held.

- On nomination by the American Society of Testing Materials, Jerome Strauss, vice president, Vanadium Corp. of America, has been elected a member of the board of directors of the American Standards Association, succeeding Dr. G. W. Thompson, who recently resigned.

Ford Steel Mill Sets World Record

Pittsburgh may be the steel capital of the world but Dearborn, Mich., is claimed to hold the world record for an 8-hr. run of cold rolled steel. The record was made recently in the Ford Motor Co.'s Rouge plant cold finishing mill. The day shift on the 66-in. 3-stand tandem mill rolled 902.8 tons of steel during its 8-hr. trick. The steel was 19-gage stock, 58½ in. wide for use in pressing body quarter panels. The Ford run beat the previous record of 855 tons in a similar period established last fall by a Pittsburgh mill.

The Ford cold finishing mill, installed 4 yrs. ago, is modern in every detail, and equipped with the latest labor-saving devices. Hot rolled and pickled coils are delivered to the finishing mill by conveyor and the workmen are required only to feed the coils into the finishing mill and remove the finished coils by hoist from the delivery end. Otherwise its operation is controlled electrically.

- The American Foundry Equipment Co., Mishawaka, Ind., has appointed Friedrick Birschel, Jr., Gaspar Campos, 1550, Vicente Lopez, F. C. C. A., Argentina, as representative in South America.

The Scrap Export Movement

The scrap export movement last year while not attaining the record proportions of 1937 was formidable and at 3,577,427 tons was the second largest, being exceeded only by that of 1937 when the total was over 4,000,000 tons, according to the *American Metal Market,* New York. It will be noted from the table appended that the shipments to Japan at over 2,000,000 tons, exceeded those for 1937, as did also those to Italy, but the United Kingdom's scrap imports from the United States were approximately 337,000 tons below the figure of 2 yrs. ago.

In the last 7 yrs. during which scrap exports have been on a relatively high scale, the total has been but 17,317,275 tons, of which Japan received the largest share by a wide margin, 9,204,000 tons.

The following table gives the U. S. consumption, exports and exports according to destinations of the chief markets over the past seven years:

	U. S. consumption	U. S. exports	To United Kingdom	To Japan	To Italy
1933	17,400,000	773,406	6,062	547,539	114,419
1934	18,800,000	1,835,170	134,434	1,168,496	225,644
1935	26,415,330	2,103,959	277,366	1,117,973	382,775
1936	36,358,133	1,936,132	364,874	1,057,621	285,126
1937	38,006,272	4,092,590	845,216	1,904,768	381,394
1938	21,344,934	2,998,591	387,347	1,381,801	434,717
1939	35,006,000	3,577,427	508,293	2,026,006	425,896
Tot. 7 years	193,330,669	17,317,275	2,523,592	9,204,204	2,249,971

Ford Constructs Unique Steel Foundry

The success of Ford Motor Co. metallurgists in developing cast steel automobile and tractor parts has led to the construction of a large new steel foundry unit in the Ford Rouge plant, at Dearborn, Mich. The steel foundry is inside the 17.7 acre Ford foundry building but is a complete unit in itself. Steel is poured continuously in the new unit, the molds being brought to the pouring spout of the electric holding furnace on a conveyor. Formerly it was necessary to pour intermittently because the steel was melted a few tons at a time in individual furnaces. In addition to saving time, the new Ford method produces more uniform castings by delivering the metal for each casting at uniform heat and composition.

The steel foundry is carefully synchronized. It includes melting furnaces, steel holding furnace, core molding machines, conveyors, heat treat and annealing furnaces, and cleaning rooms. Parts such as plow beams, tractor front axles, tractor radius rods and wheel flanges can be made in sufficient quantity for 250 tractors a day. This involves pouring from 90 to 112 tons of metal a day. A smaller foundry unit constructed nearby will produce a variety of small steel parts in comparable volume.

Another phase of the current Ford foundry expansion permits volume production of centrifugally-cast steel gears for the Ford tractor as well as for Ford cars and trucks. This method of pouring molten steel into whirling dies was described in METALS AND ALLOYS, October, 1938. The centrifugal casting unit now has a capacity of approximately 12,000 gear blanks a day.

A completely automatic method for casting the passenger car transmission housing is among the most interesting of the new developments in the Ford foundry. Molten steel runs continually from one of the two 96-in. cupolas into a 15-ton holding furnace. From the furnace, the metal flows into one of a dozen refractory-lined bowls located around the outside of a revolving table. Each bowl is automatically filled, and revolves around an axis geared to the reel until it meets the mold coming into position on the conveyor line. A cam causes the bowl to tilt at a given spot and so pour the metal into the mold. The bowl continues around to take another charge while the conveyor brings new molds into position. Approximately 125 tons of iron are poured in an 8-hr. shift.

Because of the uniform high quality and the safety the automatic method makes possible, it is being extended to the flywheel casting operation as soon as new equipment is completed.

- R. C. Enos, president, Standard Steel Spring Co., Coraopolis, Pa., announces the appointment of J. M. Cosgrove as director of the development laboratory. Mr. Cosgrove will be actively interested in research on the new corrosion proof coating developed by the company.

- Firth-Sterling Steel Co., McKeesport, Pa., announces two additions to its operating personnel. John H. Rasp, who has had wide experience in the manufacture of specialty tools and dies, has been appointed superintendent of the tool and die department of the company's sintered carbide division. J. H. Chivers has been appointed superintendent of melting to fill the vacancy created by the death of the late L. B. Knox.

- A reconstruction and expansion program recently completed at the Ryerson Steel-Service Plant in Philadelphia greatly increases service and storage facilities for steel-users in the Philadelphia area. Total floor space has been increased by approximately 250,000 sq. ft., and over 1,750 new items have been added to stocks, giving the Philadelphia Ryerson plant an exceptionally wide range of steel and allied products for prompt shipment. A new high-bay type mill building 185 by 120 ft. was erected for storing structural lines, such as beams, angles, channels, etc. Joseph T. Ryerson & Son, Inc., operate 10 large and complete steel-service plants in the principal industrial cities of the country.

(Continued on page MA 170)

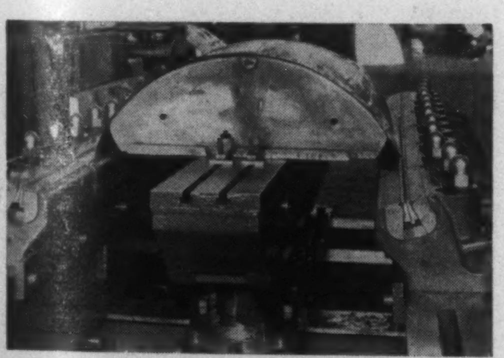
New Equipment and Materials

A Metal Stretching Press

Installation of the first metal stretching press to be built and operated in the United States has recently been completed in the huge Middle River plant of The Glenn L. Martin Co. near Baltimore, Md. Built by the Engineering and Research Corp. of Riverdale, Md., from Martin specifications and first installed by the Martin company, it is now being used daily.

Primarily, the machine consists of two hydraulic cylinders placed beneath a platen between two rows of independent clamp jaws. The cylinders are attached to the platen in such a manner that they raise or lower the platen vertically. The cylinders then operate in tandem, making it possible to obtain an angular position of the platen if desired. The controls for operating the press are conveniently located on a panel placed on a stand that may be moved to any desired point near the machine.

In operating the press a form is placed on the platen. The sheet of metal to be stretched is placed over the form and clamped tightly in both rows of jaws. Pressure is now applied on the hydraulic cylinders, causing the platen to move up—stretching the sheet tightly over the form.



When the sheet has been sufficiently stretched so that it hugs the form tightly, the pressure is released and the formed piece also released from the block. It is interesting to note that, in the stretching process, the thickness of the material is claimed to be reduced only from 5 to 7 per cent.

The entire operation takes but a few minutes; therefore, it will be readily seen that much time is saved over the former method of bumping in a power hammer or forming by the drop hammer method. Form blocks used on the press are of wood construction covered with a sheet of 0.040 gage deep-drawn body steel. The form blocks are made to the exact contour required, since there is no spring back to contend with.

The stretching press is used principally for the forming of large sheets, such as skins, engine cowlings, etc., which were formerly shaped on a power hammer.

The press does not in any way take the place of the drop hammer, but it appears probable that some parts that are now formed on the drop hammer may in the future be successfully manufactured on the new stretching press.

Manufacturers are invited to send to the Editor items which are suitable for this Department. Illustrations are acceptable, preferably in the form of cuts not more than 2 in. wide.

Hydraulic Straightening Press

Denison "Disc1 Vertical Hydraulic Presses" are designed for increased efficiency of production on straightening and similar pressing operations. The all electric welded frame of the press is fabricated of steel plate. All corners and edges of the frame are rounded.

The press cylinder assembly consists of an accurately finished steel cylinder fitted with nickel iron cylinder heads, piston, and steel piston rod. The piston rod is sealed with self-sealing packing which is subject only to low pressure and the piston is sealed with metal piston rings. The cylinder is flange-mounted in the upper portion of the "C" frame. In the throat of the press frame are located the control valves, their operating levers, and the motor starter. The hydraulic pumps, their driving motors, and the oil supply tank are in the base of the press. The motor and pump compartment is enclosed by louvr'ed panels for ventilation.

A slot runs lengthwise through the work table for positioning of dies or fixtures. The ram is guided against rotation by machined guides in the throat of the press. The end of the ram is tapped concentric with the ram itself for holding tools or fixtures. The press is a complete unit; only power connections for the motor and filling of the oil reservoir are required to put the press into operation. The entire rear panel of the press frame is removable, leaving all parts accessible for maintenance or adjustment.

The press may be operated either by a conveniently located hand lever or by a foot pedal. The pump motor is controlled from a push button located near the throat of the press. For further data, consult the Denison Engineering Co., Columbus, Ohio.

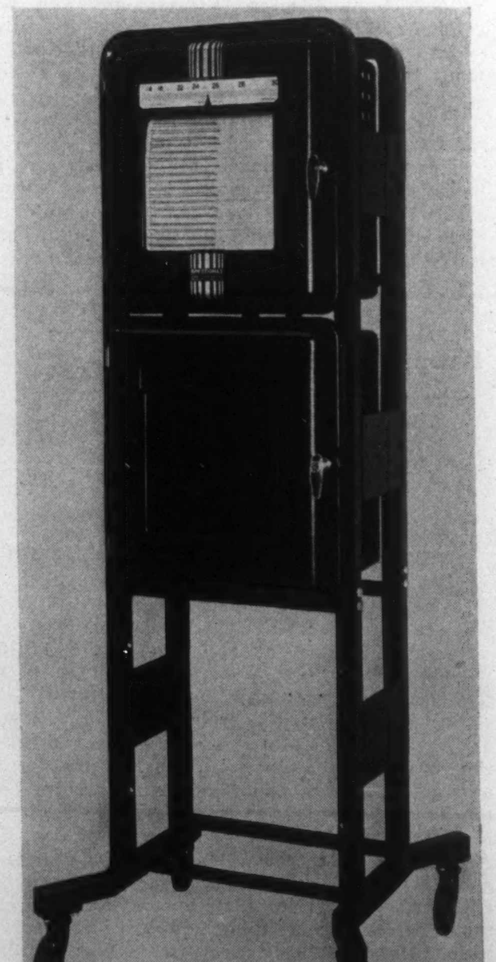
Spindle Sleeves of Meehanite

In order to maintain spindle accuracy to within one-tenth of one-one-thousandth of an inch and to provide longer life and perfect finish, the F. A. Maxwell Co., Bedford, Ohio, is now using special Meehanite castings for the spindle sleeves in connection with heat-treated tool steel spindles in their line of portable precision grinders.

Experiment has also shown, it is said, that these new spindle sleeves provide a freedom from distortion due to thermostatic action of the heat generated by operation. Grinders are for external and internal work, range in size from ¼ h.p. to 5 h.p., and provide speeds up to 25,000 r.p.m.

Speedomax Records Rolling Temperatures

High-speed recording, at a new level of dependability and freedom from attention, is now claimed possible with the completely redesigned, standardized, simplified and accessible "Speedomax" pyrometer. Speedomax draws a continuous curve of moving billet, slab, rail, etc., temperature. Showing not only temperature of the work, but also temperature gradient between its ends, this chart is a reliable guide to rolling mill operations.

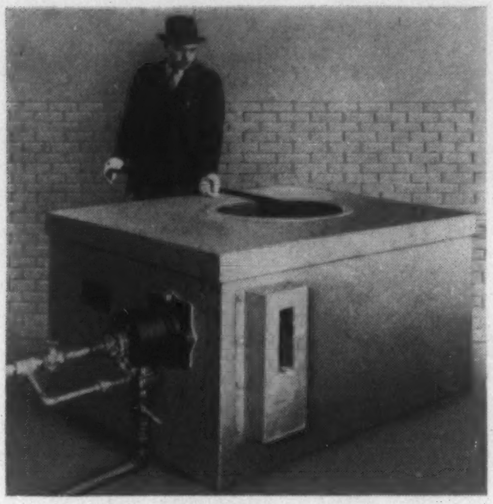


There are many other uses for the Speedomax recorder. In the field of scientific research, for instance, they include the recording of: Temperature, pressure and humidity measurements radioed from high altitudes; speed, radio field strength and microphotometer measurements.

Made by the Leeds and Northrup Co., 4934 Stenton Ave., Philadelphia, Speedomax is described at length in its new 12-page illustrated bulletin, N-33B-685(1). A copy of this booklet and information specific to your problem may be obtained by writing to the company.

Pot Melting Furnace

A new type of pot furnace, which has as a particular feature approximately 30% recuperation of fuel, has been introduced by A. F. Holden Co., New Haven, Conn. This equipment can be built in either oil or gas-fired units and the difference in it and the conventional types is that there is one exhaust to this equipment. This unit has a specially constructed wall so that the exhaust gases pass at right angles to the incoming fuel. By this method of heating the gas or oil is preheated before it actually enters the chamber and the terminal velocity of gases passing out of the exhaust is only sufficient to support combustion. The gases are slowed down approximately 50 per cent in their travel from the exhaust and therefore greater efficiency and economy is provided in the burning of fuel.



An additional feature claimed for this equipment is the fact that the pot becomes a part of the top framework of the furnace so that no seepage into the brickwork is possible around the top of the pot.

This equipment can be made in any size in which case there may be more than one burner and one exhaust. However, for conventional size equipment, running up to 24 in. in diameter, one burner and one exhaust will deliver maximum efficiency.

High Temperature Laboratory Furnace

The new Burrell high temperature furnace, "Type K," is not a muffle but rather a box type furnace producing temperatures up to 2550 deg. F. The articles to be heated are exposed to direct radiation from the non-metallic, Burrell brand heating elements located in the roof.

The heating chamber measures 4 by 4 by 13¼ in. deep. The floor is a removable, refractory plate with molded sides to prevent spillage from reaching the insulation. Overall outside dimensions of the furnace are 26 in. wide by 30 in. high by 24 in. long. The heating elements are designed to give long life but when it is necessary to replace them, this operation can be done in 5 mins. without cooling the furnace. The Burrell Type K Furnace requires 2.4 k.w. to maintain the temperature of the heating chamber at 2550 deg. F.—2.3 k.w. for 2500 deg. F., and 1.4 k.w. for 1800 deg. F. A thermocouple protection tube is standard equipment and the furnace can be supplied with or without No. 6028 pyrometer. Burrell tap transformer with switchboard No. 6077, supplied separately or mounted on metal table, is recommended to control the temperature.

The complete outfit including Burrell High Temperature Furnace Type K, together with pyrometer and tap transformer with switchboard mounted on metal table, is priced at $415.

"Metcolizing" to Prevent Oxidation

A process for the economical and efficient protection of iron, steel, and in some cases copper and bronze, against oxidation and scaling at elevated temperatures is named "Metcolizing" and is offered by the Metallizing Engineering Co., Inc., 21-07 41st Ave., Long Island City, N. Y. It is also recommended for the protection of nickel and nickel-chromium alloys against attack by sulphurous gases. Full information is available from the company.

Pellets or Cones for Temperature Control

The newest technique in temperature control is claimed for "Tempils." Tempil pellets have a sharp and rapid melting action at the stated temperature. Thus, Tempil 200 melts at 200 deg F. and Tempil 300 melts at 300 deg. F., etc. They are accurate within 3% of the temperature which they are intended to indicate.

Each Tempil is stamped with the temperature at which it melts. Tempils liquefy sharply and unmistakably at the stated temperature. In addition, each range of Tempils is made in a distinguishing color for easy identification. In application Tempils are merely placed upon or against the heated object. When the Tempil melts the heated object has reached the temperature stated on the Tempil. They are available in whole hundred degree ranges and on request may also be had in 50 deg. F. intervals.

Tempils are especially valuable in determining temperatures in the black heat range. The importance of controlling temperature below 1000 deg. F. is becoming increasingly recognized. They are rapidly becoming standard practice for pre-heating temperature determinations in welding. Other uses readily suggest themselves, such as signaling maximum and minimum temperatures in a variety of industrial arts, and countless other applications.

From Cupaloy Comes Cuferco

When the "Time Capsule" was constructed, Cupaloy was a unique metal; but even before the Time Capsule has been finally interred, there comes from the metallurgical research laboratories of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., a new and even more remarkable member of the Cupaloy family of metals. Developed by J. M. Kelly, Westinghouse research metallurgist, and named "Cuferco," from the chemical symbols of its three components (copper, iron, cobalt), the new alloy resembles Cupaloy in appearance, but it is easier to make, has greater strength, higher heat resistivity, more mechanical endurance, and a somewhat lower electrical conductivity.

The iron-cobalt content of Cuferco is highly important in determining the characteristics of the alloy. For best composition, identical quantities of the two elements must be used, the normal proportions being about 96 per cent copper and 2 per cent each of iron and cobalt. Electrical conductivity of the alloy is about 70 per cent as good as that of copper, and at the same time it has about the same tensile strength as hot-rolled low-carbon machinery steel.

Because of its iron content, Cuferco can be hardened by heat treating. Brass and bronze, on the contrary, must be hardened by cold working, and once they are overheated their hardness is lost forever. Cuferco is softened very little by repeated applications of heat. Consequently, it is expected to be good for such things as tips for spot welders. The tensile endurance limit of the new metal is 23 per cent higher than that of Cupaloy. If somebody wants an even stronger metal, it is simple enough to accomplish by adding a little beryllium to Cuferco—but then it isn't Cuferco any more. It is another new member of the Cupaloy family.

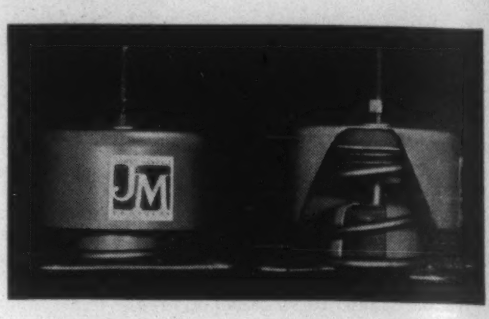
Accurate Checking of Fillet Welds

A new low-priced fillet-weld gage has been developed by the General Electric Co., Schenectady, N. Y., to meet a long-felt need on the part of welding inspectors and operators for a fast, accurate means of checking the size of fillet welds on jobs which have to meet rigid specifications. The new device, which slides readily into a shirt or trouser pocket, is described as of extremely simple construction, consisting of three stainless-steel stampings held together by a bolt and a knurled thumbnut. Either convex concave or Standard fillets can be checked merely by fitting the edge of the gage flush against the work so that the indicating portion of the gage rests on the weld bead. The gage can be used on fillets of the following sizes: 5/16 in.; ⅜ in.; ¼ in.; 5/16 in.; 7/16 in.; ½ in.; and ⅝ in. These sizes are clearly marked in black on the gage.

A Machine-Vibration Isolator

A new, easily installed vibration isolator, designed to economically control machine vibration and reduce the resulting noise, has been announced by Johns-Manville, 22 E. 40th St., New York. The device, known as the "J-M Controlled Spring Isolator," was developed for use on the bases of motors, generators, pumps, ventilating fans, and similar equipment where vibration and excessive motion create noise and tend to wear out machine parts and damage connections as well as crack the supporting walls and floors.

The working parts of the unit consist of a coil spring and a rubber load pad, which support the equipment and isolate vibration, and an adjustable rubber snubber inside the base, which controls excessive motion. Through the combination of these parts, the manufacturer states, the isolator provides both the high compliance necessary for good isolation and the control needed to limit motion in the equipment.



The isolator was built to take care of horizontal and torsional as well as vertical vibration, and tests by the J-M Research Laboratories, where the unit was developed, indicate it to be particularly efficient for the low frequency vibrations resulting from slow speeds and from many operations involving reciprocal action. The load pad is designed to overcome any high frequency vibrations.

The isolator is made in two sizes: Light duty, for loads from 60 to 190 lb. per isolator; and heavy duty, for loads from 250 to 720 lb. per isolator. Heavy machines may be isolated by clusters of the units. The loaded overall dimensions of the isolator are 6 by 6 in. by approximately 3¾ in. high. It is enclosed in a metal jacket which protects the rubber parts from oil and light.

For Stripping Protected Metals

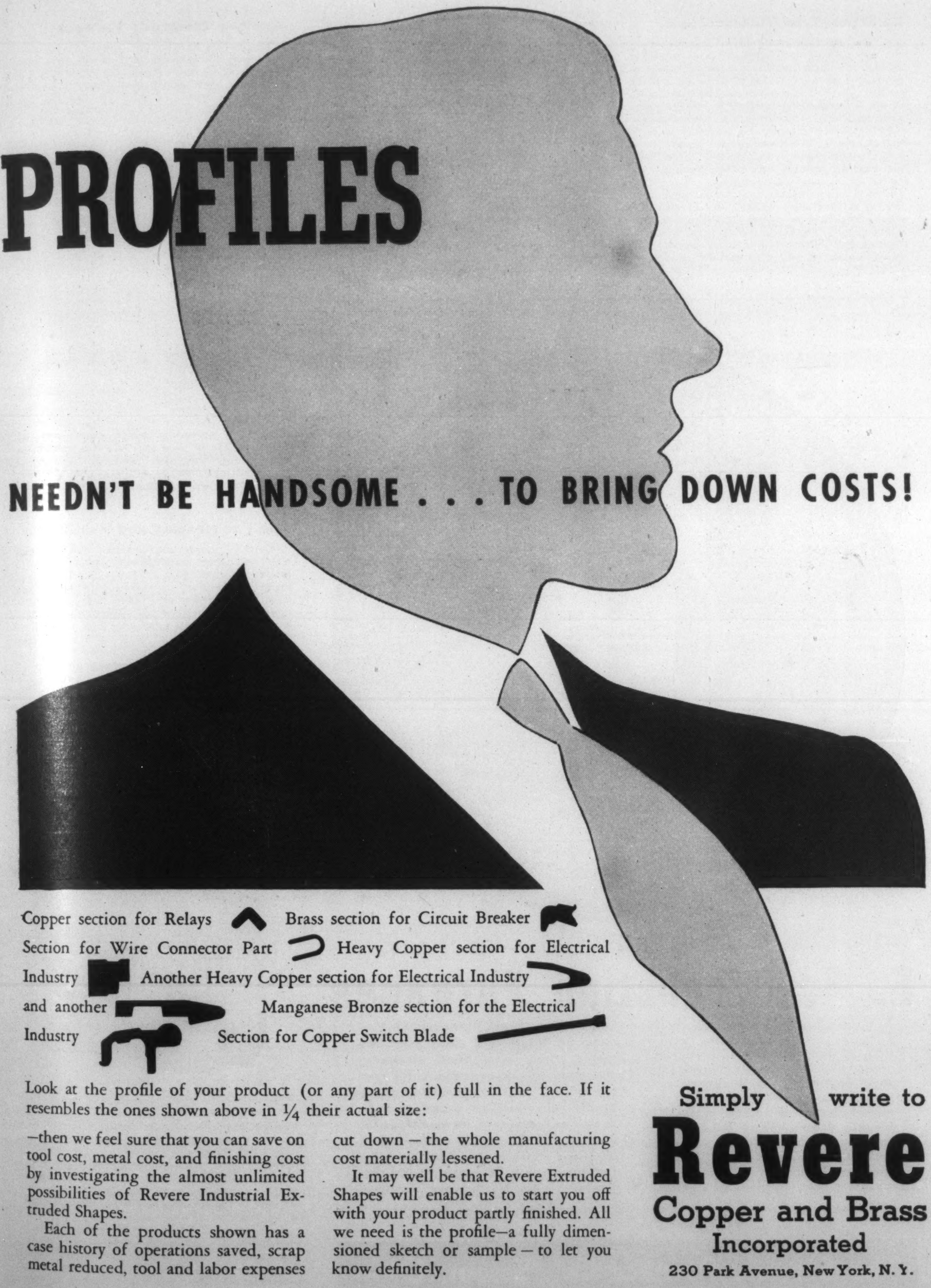
"Metastrip," developed by the Surface Finishing Products Co., New Haven, Conn., is a composition for stripping baked enamels, varnishes, lacquers, paints, japan, etc., from metals such as steel, zinc, alloys, and so on. It is described as an opaque liquid about the color of cream which contains no caustics but depends on emulsifying agents for its action. It is claimed to float the finished surface away from the metal in about 2 mins. or less.

Metastrip is maintained at a heat of about 190 to 213 deg. F. and the work is immersed in it. The work is then taken out and rinsed in hot water. This is said to result in a clean bright surface. Zinc, steel, brass, bronze, aluminum, tin, copper, alloys, etc. are claimed unaffected by the action of Metastrip.

New Buffing Lathe

A new buffing lathe, "Type MO," designed for a range of work not requiring a heavy duty machine has been developed by the Hanson-Van Winkle-Munning Co., Matawan, N. J., manufacturers of electroplating equipment and supplies. A generous overhang for clearance is furnished. The body of the lathe is a heavy one-piece iron casting and the base dimensions of all sizes are 24 in. wide by 20 in. deep. Drive is by V belt, with quick belt changing a special feature. Any one spindle speed from 1800 to 3600 r.p.m. can be obtained and other speeds can be had by changing the motor sheave pulley. The spindle is of 1¼ in. to 1¾ in. alloy steel. Type MO lathe is furnished for 220, 440 and 550 volts, 2 or 3 phase, 60 cycle, A.C. power circuit; also for special or other A.C. or D.C. circuits.

(Continued on page MA 180)



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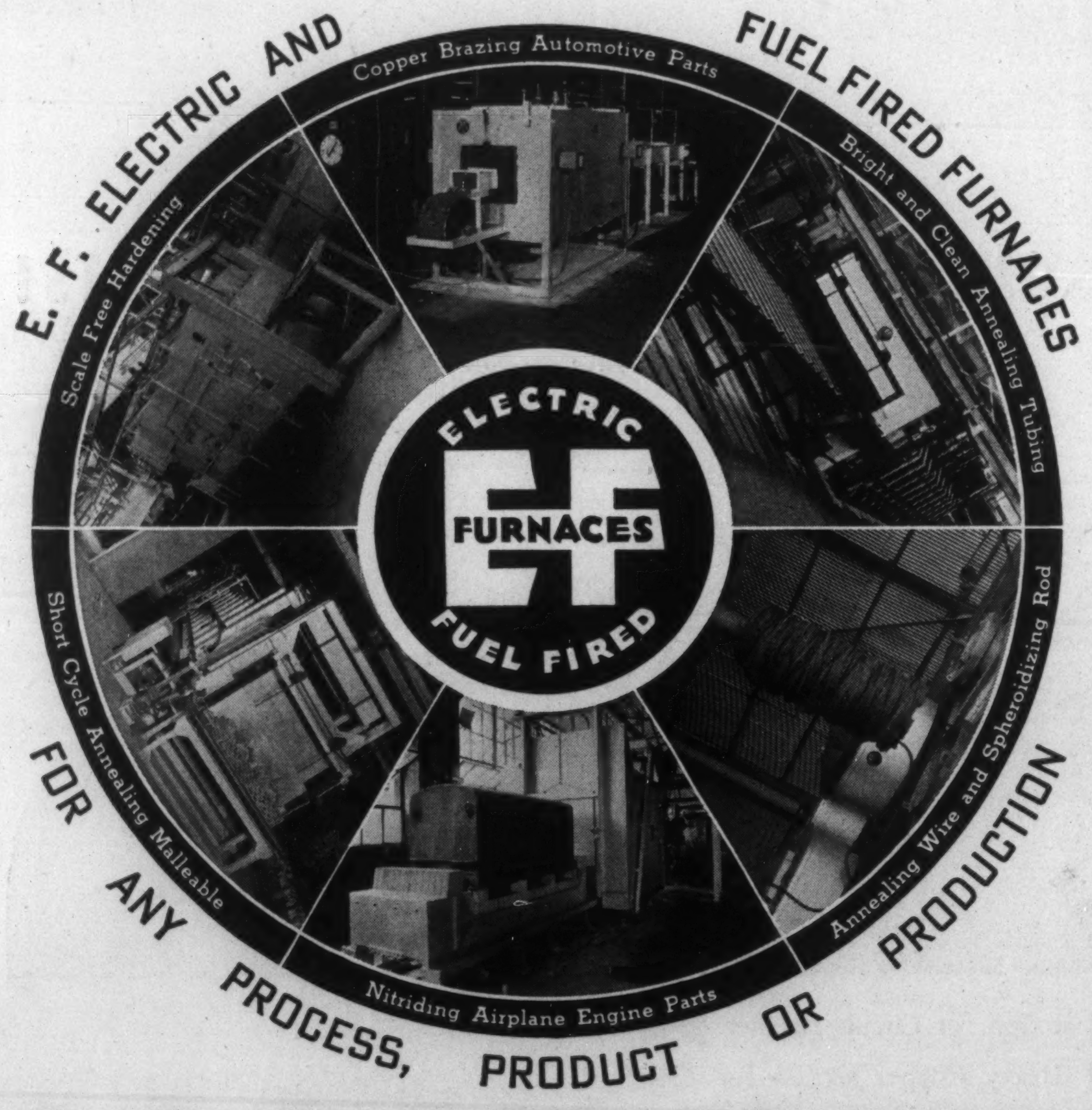
Radiation-Type Thermocouple

A new radiation-type vacuum thermocouple for use wherever exceptionally high sensitivity and very rapid response are needed has been announced by the General Electric Co., Schenectady, N. Y. This thermocouple is designed to fill a specific need created by the development and use of controlled protective-atmosphere furnaces for processing materials at high temperature. Possible applications include temperature measurement and control in brazing, heat-treating furnaces, glass heat-treating, infra-red drying and solar radiation.

Enclosed in a vacuum, the thermocouple consists of a very thin filament of two different metals, blackened on one side. Radiant energy acting upon the thermocouple produces an electromotive force which is transmitted to a millivoltmeter or potentiometer which can be calibrated in degrees. The device may be mounted either temporarily or permanently upon a furnace, the only accessory needed being a closed-end tube in the furnace to prevent fogging of the lens and to form a target upon which to sight the thermocouple.

Since the thermocouple has no physical contact with high-temperature furnace parts it will not be damaged by high temperatures. Temperatures from 300 to 1500 deg. C. can be read on a millivoltmeter or potentiometer. Still higher temperatures can be handled by the addition of protective screens or filters between the thermocouple and the heat source.

On the General Electric production lines, this new instrument has been found particularly useful in controlling temperatures of rapidly moving objects and materials on conveyors through furnaces.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E. F. Production Furnaces

E. F. Gas Fired, Oil Fired and Electric Furnaces are helping speed production, improve quality and lower operating costs in many prominent forge shops, automotive and aircraft parts plants and many other ferrous and non-ferrous metal working plants. The Electric Furnace Co. specializes in building production furnaces and time and labor-saving material handling auxiliary equipment to fit the customer's particular plant and product. Recent E. F. installations include furnaces for bright and clean annealing tubing, strip, wire, sheet, stampings and other products—furnaces for copper brazing, heat treating and annealing without scale or decarburization as well as furnaces of various types for normalizing, short cycle malleablizing, nitriding, enameling, carburizing, billet heating, heating for forging and other processes. We solicit your inquiries.

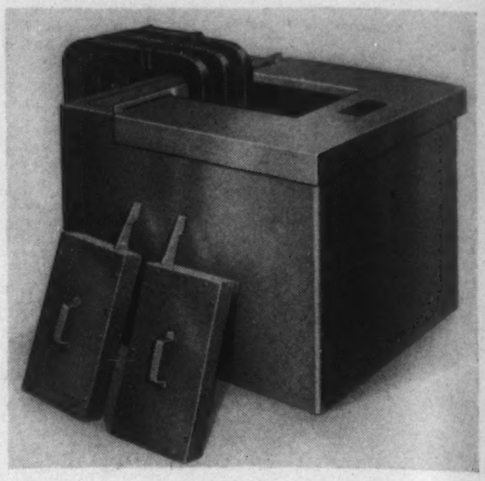
We build the furnace to fit the job—No furnace is too large or too unusual.

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

Another Electrode Furnace

The A. F. Holden Co., New Haven, Conn., announces "a new design, three-phase electrode furnace which has vertical individual adjustable electrodes. These electrodes may be used on the narrow width of this type furnace up to 30 in. length.



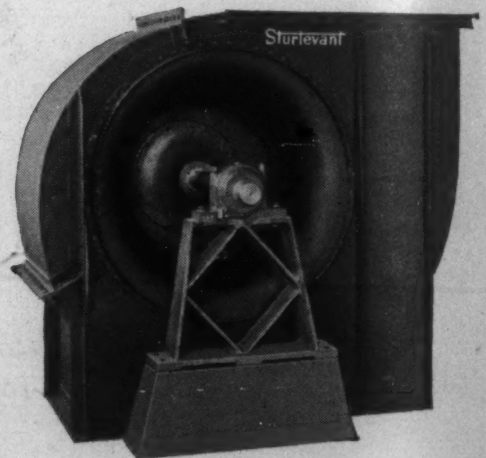
"There is a cover plate on this furnace for loading or unloading which drains any bath back into the furnace and this construction permits loading from three sides.

"Hand operated covers are used for overnight shut-downs or small individual loads."

Fan For Heating and Ventilating

Reduced power consumption, quieter operation and less maintenance characterizes the latest addition which B. F. Sturtevant has made to its line of centrifugal "Silentvane" fans. Known as the "Silentvane Design 7," this fan is described as ruggedly constructed of heavy steel plate reinforced with angle irons, and as suitable for all types of heating, ventilating and industrial applications. Chief of its outstanding claimed advantages are the following:

(1) Slow rotative and peripheral speeds—less vibration, longer life, yet no more floor space required; (2) Quiet operation resulting from streamline inlets shaped to form whirl-free passages for the air to enter the rotor smoothly, reducing fan-eddy currents and turbulence; (3) High efficiency over a large operating range. Mechanical efficiencies in excess of 70% are obtained over 53% of the performance range;

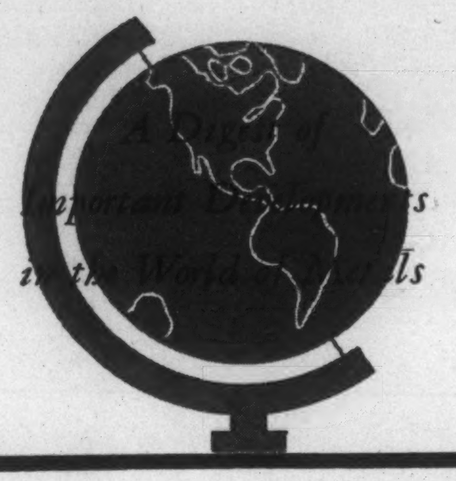


75% over 41% of the performance range; and 80% over 21% of the performance range; (4) Self-limiting horsepower characteristic with gradually increasing horsepower and volume until the point of maximum efficiency is reached; then decreasing horsepower for larger volume; and (5) Freedom from dust loading in rotors or fouling when handling dirty gas or air, due to the use of straight fan blades pitched at an angle of 45 deg. at delivery.

The Design 7 Silentvane Fan is available in all standard discharges, single and double width, single and double inlet, with wheel diameters ranging from 14⅝ to 87 in., static pressures to 16 in. w.g. For further information write for catalog No. 451. B. F. Sturtevant Co., Hyde Park, Boston.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS



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1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

5. General

Articles pertinent to more than one of the previous sections.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

Testing Molding Sand

PHYSICAL TESTING OF COMPRESSED MOLDING SAND AND ITS SPECIFIC COMPRESSIBILITY ("Einiges über die physikalische Prüfung des verdichteten Formsandes unter Berücksichtigung der spezifischen Verdichtbarkeit") W. REITMEISTER. *Giesserei*, Vol. 26, Dec. 1, 1939, pp. 577-584. Investgation.

The condition of a compressed sand specimen influences the test results obtained therefrom and must be considered in any practical interpretations of such tests. It is illuminating to consider the relationship between the weight of the specimen (E) and its volume (V). The weight (E) depends upon (1) the specific gravity of the sand itself and its water content, (2) the grain sizes, distribution, and shapes, (3) the compression energy applied in the test, (4) the "specific compressibility" of the sand water mix. A useful measure of the condition of the specimen is E/V ("specific weight of form").

The reciprocal value V:E (called the specific form volume) indicates the space in cc. taken by 1 kg. of sand after compressing. The compression is determined by $(V_a—V_e)/V_a$, where V_a is the volume at the beginning, V_e that at the end of the compression. For example, 1 kg. of sand is poured loosely into a standard test tube of 28.3 cm.^{2} section and occupies a height of 43.5 cm.; the specific form volume is 1231.05 cc. If after 500 compressing strokes from a 1-cm. height the column of sand is only 24.3 cm. high, the specimen has a specific form volume of 687.69 cc.—a reduction of 44.1%.

The specific compressibility of a sand-water mixture is expressed by the percentage reduction of the original loose volume after compression by a compression energy of 500 kg.-cm./kg. sand. A table of 4 different sands shows specific compressibilities ranging from 35.7 to 44.1.

The gas-permeability of a sand is given by $G_p = J \times 0.4 \times h/g \times t$, where $J \times 0.4$ is the volume of gas escaping from the testing apparatus under a pressure decrease from 0.5 to 0.1 atm. pressure, h is the height of the specimen, g is the section of specimen (28.3 cm.^{2}), and t is the time in sec. required for the pressure decrease from 0.5 to 0.1 atm. The gas-permeability is thus the volume of air per sec. passing through 1 cc. sand with a pressure decrease from 0.5 to 0.1 atm. The specific compression resistance is given by $W = G \times h/F \times t$, where G is the dropping load used for compressing, h is the height of the fall, F is the section of the dropping load, and t is the depth of penetration.

The apparatus used for these determinations and tests made with them are described in detail, and results with different sands are shown in tables and curves. The sand testing method and apparatus of Reitmeister (*Metals and Alloys*, Vol. 3, Apr. 1932, p. MA 108) are stated to be generally satisfactory, while the standard method prescribed by the (German) DVM is not satisfactory in this respect. Ha (1)

1a. Ferrous

Refractories in Steelworks

A Composite

Steady improvement in recent years in the general quality of steel has been attended by constant betterment of refractory quality and by more intelligent application of available refractories. Some of the steelmaker's refractory-application problems are discussed in articles recently published in British and American magazines—all of which pay much attention to the greater use of basic brick throughout open hearth furnaces. In this respect readers of this digest should certainly study the article by R. P. Heuer published as the first feature article in this issue of METALS AND ALLOYS, which pleads so eloquently for the use of basic brick in open hearth roofs.

Correlation of the properties of refractories with their service performance in different sections of the open-hearth furnace is highly desirable. J. C. Hayman ("A Method of Allocating Refractories Consumption in the Open-Hearth Furnace," *Trans. British Ceramic Soc.*, Vol. 38, Oct. 1939, pp. 529-535) describes a system employed for this purpose in the various plants of a large British steel company. The system includes a procedure for presenting data periodically in the form of furnace-campaign cost reports. Hayman presents a separate analysis of the data thus obtained ("Evaluation of Basic Refractories," *Trans. British Ceramic Soc.*, Vol. 38, Oct. 1939, pp. 536-553), which reveals a definite correlation between laboratory tests and service performance for two brands of chrome-magnesite brick.

The laboratory tests included an iron oxide absorption test, the technique of which is described. The two brands were tried in the front wall of 75-ton stationary furnaces. The use of chrome-magnesite in place of silica and magnesite in this position was decidedly advantageous from the standpoint of cost. Chrome-magnesite brick were also found to be more economical than silica brick in the gas ports of a stationary furnace, but in the furnace blocks severe disintegration due to iron oxide absorption, accompanied by fusion of portions of the chrome-magnesite, brought about early failure. An examination of various samples of used brick strongly indicated that the fusible material draining from the chrome-magnesite brick had a corroding effect on the silica brick used at lower levels in the uptake.

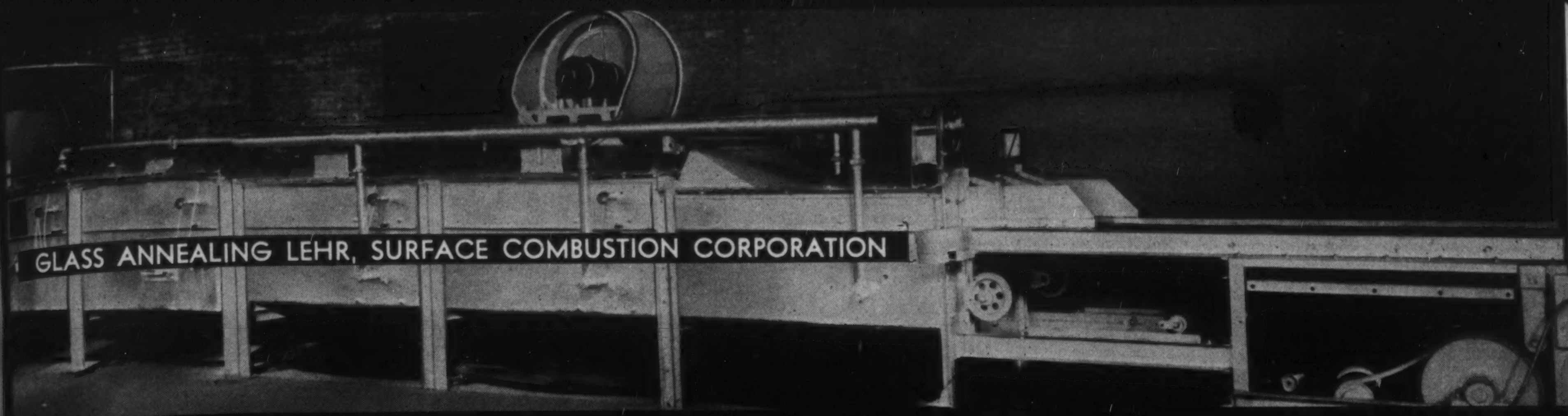
Conversely, silica drip on the banks is a costly problem, and A. M. Morton of Pittsburgh Steel Co. ("Refractories in The Open Hearth Furnace of 1939," *Blast Furnace & Steel Plant*, Vol. 28, Jan. 1940, pp. 47-49) advocates the use of basic brick shoulders along the front and back sections of crowns to eliminate the condition. Like Hayman, Morton strongly favors the use of basic brick wherever possible, but points out that the first cost of basic brick sections, for the application just mentioned have not yet been justifiable on an operating-cost basis.

On the other hand while the higher cost of a basic front wall, as compared with a silica front wall, is not justified from a brick cost basis, it can be justified if the cost of chrome ore for repairs and of delays to install the silica front walls are considered.

In a few plants, silica brick are being used to top out checkers, as are high-alumina brick of various types, but the general practice is to use first quality clay brick. Checker brick performance seems to be governed by the type of fuel burned and furnace design.

This relationship between refractories performance and fuel- and furnace-types is broadly indicated by B. Thomas ("Choosing Refractories," *Proc. Staffordshire Iron & Steel Inst.*, Vol. 54, 1938-1939, pp. 16-29), who stresses the careful selection of refractories with full consideration of combustion factors — particularly in smaller steel mill furnaces. High-alumina refractories are best for pulverized-fuel furnaces and siliceous types for high-temperature stoker-fired units.

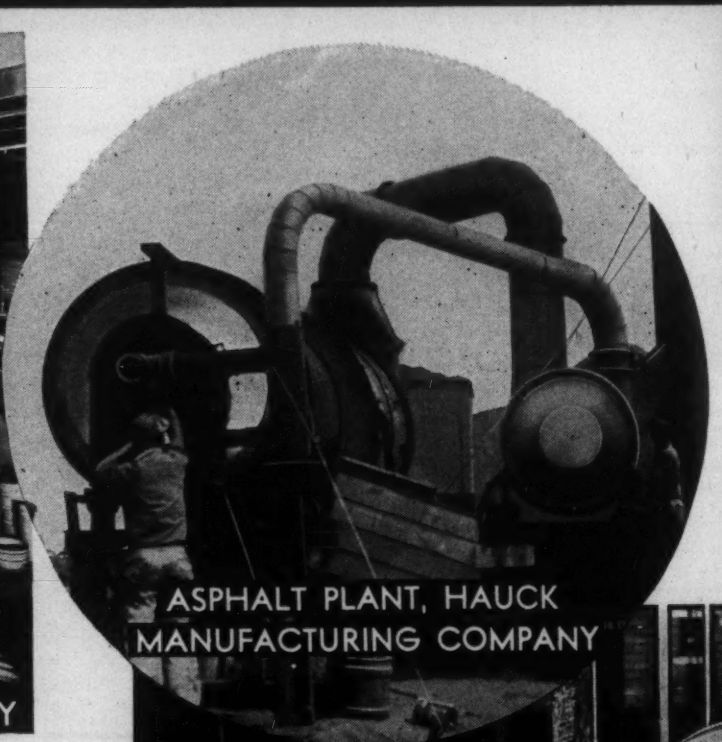
Morton states that with oil or natural gas as fuel in open-hearth furnaces, gas and air uptakes are usually constructed of silica brick. When basic roofs are perfected, natural gas should be an ideal fuel, since full advantage can be taken of its economical high-temperature possibilities. The use of basic brick in air uptakes is an individual problem. In some cases, small coolers in the air uptakes are eco-



GLASS ANNEALING LEHR, SURFACE COMBUSTION CORPORATION

CERAMIC APPLICATIONS

KILNS, ALLIED ENGINEERING COMPANY



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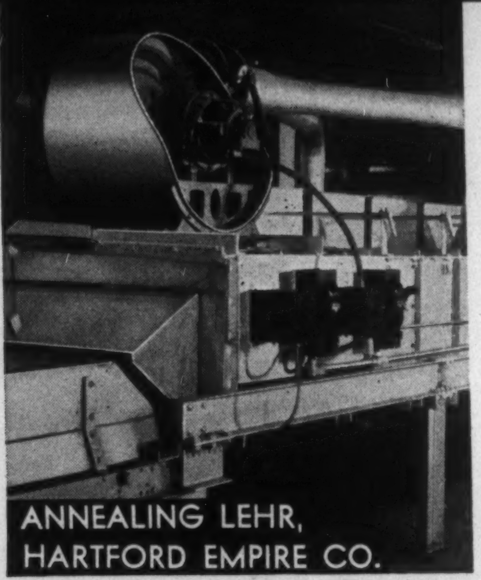

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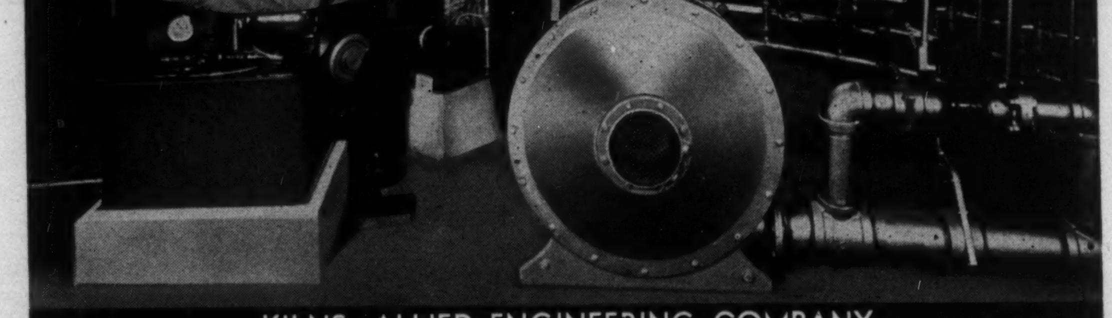

KILNS, ALLIED ENGINEERING COMPANY

Heating operations in the ceramic field have many points in common with the heat treating field. For one thing, many of the equipment manufacturers that have developed modern heat treating equipment also furnish equipment for lehrs, kilns, enamel ovens and miscellaneous heating units.

In common with heat treating, a smooth continuous flow of clean dry air is essential for close control and perfect timing.

Also, as in heat treating, the majority of equipment manufacturers in the ceramic field prefer and recommend Spencer Turbo-Compressors.

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nomical where silica brick are being used in the walls.

Basic ladle linings are being tried, sometimes with much success, in several shops. At least 1 in. of insulation should be used against the steel jacket to prevent spalling with sudden changes in temperature. Many kinds of fire clay are used with the brick in lining ladles, and there is still some loam used for this purpose. However the clay used should be at least as good as the brick and, preferably, much better, as clay inclusions in the steel add nothing to its quality. X (1a)

Monolithic Cupola Lining

"Practical Application of Monolithic Lining in Cupolas." F. Oldershaw. *Foundry Trade J.*, Vol. 61, Dec. 7, 1939, pp. 385-386. Production research.

The cupola used for the experiment was solid-bottomed, approximately 6.5 ft. dia. inside the shell. It was stripped of the old brick lining with the exception of the outside course of bricks measuring 4.5 in., which were left in their original position. A circular former 43 in. in diameter was then placed in position, allowing for an equal thickness of 13 in. of rammed lining to be installed.

The material used was a proprietary monolithic lining material—largely ganister and clay. The clay part should be weathered to develop maximum plasticity. Drying-out of the lining should be carefully and slowly performed, requiring several days.

The cupola in this experiment was put to work on June 25, 1936. The weight of metal melted during the first blow was 59 gross tons, and the melting rate was approximately 9 tons/hr. On examination it was found that the lining face was solid, sound, and well vitrified.

After 6,000 tons had been melted, it was noted after each blow that although the bricks used for patching had been destroyed, the plastic patching (of same composition as the lining) stood out in ridges between the remaining bricks. A patching procedure was therefore evolved that dispensed with the use of bricks. Instead, an air-dried unburnt block with slots in the sides and ends for fixing, and made of the same material as the patching and lining, was die-formed in a press. After air-drying in a warm place these were ready for use.

Double-lining successfully overcame the weakness of ordinary monolithic linings about 5-7 in. from the lining face. Only a small amount of patching is used after each blow, so that the material was vitrified from back to front, thus forming a lining with the strength of firebrick but without the undesirable joints.

More damage is done by careless and irregular charging at the beginning than during the rest of the blow. However, a fluctuating blast (stopping and starting every hour or so) is often responsible for serious cracking or spalling of the patching near the tuyeres. For best lining life only large coke should be used, so that the blast will flow easily and penetrate evenly into the cupola, without the side-wall blast-diversion that accompanies the use of small coke.

To obtain consistent results from a monolithic lining in a cupola, the following precautions should be applied: Avoid small coke for the bed; keep the tuyeres clear; use large-size tuyeres rather than small; keep blast and temperature regular throughout the blow. AIK (1a)

Progress in Iron and Steel Making

"Developments in the Iron and Steel Industry during 1939." W. H. Burr (Lukens Steel Co.) *Iron & Steel Engr.*, Vol. 17, Jan. 1940, pp. 52-71. Review.

Activity in the coke plant field during 1939 was limited largely to rehabilitation and improvements in existing plants. The trend is definitely toward the continuous methods of recovery wherever possible. Immense reserves of high grade ore in this country have delayed serious steps toward beneficiation of ore, but the southern plants are finding increased economy in proper ore sizing and in proportional mixing of ores to attain a constant analysis. Eastern magnetite ores are also being conditioned.

Sulphur control in pig iron is largely effected by slag-metal reactions within the furnace, but considerable interest is being shown in ladle desulphurization using caustic soda or calcium carbide and sodium chloride. The sharp rise in steel activity during the latter part of the year caused many blast furnaces to be blown in, a large number of which required relining or modernization. Where possible, hearth, bosh and stockline diameters of the older furnaces are being increased, as well as furnace height. This increase in height tends to keep the ratio of furnace volume to the areas of hearth and bosh at about the same values, which generally have been held to be most economical.

Improved radial distribution of the gases within the furnace is receiving attention because of its effect on furnace efficiency. The heating of the blast for blowing has also come in for its just share of study, and with improved gas cleaning, more efficient stove checker-work is being adopted. One design finding considerable favor uses a 2½ in. brick thickness and a 5¼ in. checker opening in which fillers are placed up to within a short distance of the top. Blast temperature is automatically controlled by mixing some cold blast from the blowers with the hot blast from the stoves. Better mixing is obtained by introducing the cold air at the bottom of the hot blast valve drum on each individual stove.

Equipment for the air-conditioning of the blast for a southern furnace was installed to eliminate the deleterious effects of high and varying humidity in the blast. The process employs a spray type dehumidifier, where the air passes through three sets of sprays of refrigerated water. The air is then delivered to the blowing engines. Conventional gas cleaning systems have also undergone considerable improvement, with electrical precipitators added to obtain a high degree of cleanliness. A typical precipitator lately installed will clean 55,000 cu. ft. per min. of blast furnace gas at standard conditions to a final cleanliness of 0.025 grains/$ft.^3$ The precipitator unit may be superimposed upon a primary cleaner.

Special deoxidizing and scavenging agents are finding increased use both in rimmed steel and in the finer specialty steels. When silico-manganese is added to rimming steel shortly before tapping, a cleaner, better steel is produced, and its tendency to age-hardening is decreased. The use of low-carbon or medium-carbon ferromanganese in place of standard ferromanganese is said to be a way of obtaining a lower carbon content and, there is reason to believe, of reducing the age-hardening characteristics of sheet steel. Oxidation of the bath need not be so severe, the heat can be tapped from 15 to 30 min. sooner, and the furnace output can be increased. The finished steel will be free from hard manganese carbide areas, and will have improved cold-working properties.

Zirconium alloys are increasingly used in high-impact steels as deoxidizers, for grain-size control, and to minimize the detrimental effects of nitrogen and sulphur. An alloy containing 12 to 15 per cent zirconium and 39 to 43 per cent silicon is generally suitable for this purpose.

There is a marked trend toward the use of open hearth ladles of all-welded design, including trunnion construction and reinforcement members. The trunnions proper may be solid steel forgings with a shank extending through the ladle shell, to which it is fully welded. An important result of the new design is a saving in ladle weight of about one-third, which is of particular value in plants desiring to increase the size of their open hearth furnaces, but limited as to ladle crane capacity.

The Bessemer process has recently become a subject of renewed interest. An efficient method of melting scrap is being sought so that both molten iron and molten scrap may be used in the process. Another development involves better control of the process, by using a photoelectric cell to record the intensity of the Bessemer flame. These records are calibrated so that performance may be duplicated in subsequent operation.

Only one continuous hot strip mill was put into operation in the United States during 1939. This mill is a 54-in. unit, and follows conventional design, except for one unusual feature: the installation of a vertical coiling unit in addition to the two usual horizontal coilers. The trend in cold mills is toward higher speeds and heavier power.

One of the pioneer wide-strip mills was revamped and brought into substantial agreement with the conventional hot mill layout, although possessing several unusual features. One of these is the use of a flame-scarfing machine, which conditions the hot slab surface as it passes from this mill to the strip mill reheating furnaces. This unit satisfactorily removes defects from both sides of the slab, allowing hot charging into the reheating furnaces.

The year of 1939 has witnessed a marked growth of the portable radiant-tube annealing cover in wire and high-carbon specialty applications, for all phases of rod and wire spheroidizing, bright annealing, and process annealing. Much attention was given to the proper furnace atmospheres to be used in these operations, so that much pickling and cleaning is eliminated, and decarburization is prevented. The use of cracked ammonia atmospheres affords a means for surface carbon control. Furnace base design has been modified so as to further guard against air infiltration. Alloy sheaths over all base refractories eliminate contact of the atmosphere gas with them.

There has been a noticeable trend throughout the steel industry toward a more careful selection of refractories to meet the specific needs of the definite job. With higher production rates, and consequent increased penalty from furnace shutdowns, the accent has been not so much on the first cost of refractories but on the proper choice of refractories to better withstand more severe service conditions and provide greater continuity of furnace operation. In other words, ultimate overall cost is now the criterion, rather than first cost.

Instrument and control makers have done much toward improving the appearance of their products, as well as their accuracy and reliability. One manufacturer announced a reset potentiometer controller for continuous processes, combining a potentiometer temperature measuring system and an air-operated control mechanism. This instrument can be used for automatically controlling temperatures up to 3,000° F., and

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Powdered alloys will be important products of the new plant. Used as master alloys, such powders can be added to the powdered mixtures of base metals and handled by standard powder metallurgy methods without risking the loss of expensive alloying elements.

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the throttling range and rate of reset may be changed over a wide range by a simple adjustment to suit the process involved.

A flow ratio control device recently brought out may be applied for proportioning air and fuel gas, for proportional mixing of fuel gases, for proportioning lean oil and wet gas entering an absorber, and similar uses. Another manufacturer completed an installation of meters measuring flow of gas to soaking pits in terms of Btu., the volumetric rate of flow being automatically compensated for changes in Btu. value of the gas as measured by a master recorder which determines Btu. per ft.^{3} of gas. A thermal converter has recently been developed which, with either a direct-deflecting millivoltmeter or a potentiometer, can be used to measure a.c. power in an individual circuit, to totalize a.c. power in a number of circuits, or for telemetering a.c. power or total load. CBJ (1a)

Producing Low-Hydrogen Steels

THE EFFECT OF HYDROGEN ON VARIOUS STEELS ("Die Wirkung von Wasserstoff in Stählen verschiedener Zusammensetzung") W. EILENDER, Y. C. CHIN & F. WILLEMS. *Archiv Eisenhüttenw.*, Vol. 13, Jan. 1940, pp. 309-316. Research.

Plain carbon and alloy steels were melted in a 200-lb. induction furnace under a hydrogen atmosphere, variously deoxidized, and studied with respect to hydrogen evolution during solidification.

The rate of hydrogen evolution decreased with carbon content. The addition of alloying elements had a similar effect. Columbium-bearing steels, however, were an exception to this rule, the rate of hydrogen evolution *increasing* with increasing columbium.

Columbium may possibly be useful as a dehydrogenizing element. Thus, additions of from 0.24 to 1.3% columbium caused rapid evolution of hydrogen after melting, leaving lower amounts of hydrogen in the solid steel. It is suggested that such steel may be less susceptible to the formation of flakes. SE (1a)

Open-Hearth Slag Control

A Composite

Rapidly becoming one of the steelmaking engineer's most useful tools, slag control is still "somewhat misunderstood," if we are to judge by the remarks of a recent lecturer and by the prodigious amount of research being done to increase our understanding of this subject. Delivering the A.I.M.E.'s 17th Howe Memorial Lecture (abstracted in *Steel*, Vol. 106, Feb. 26, 1940, pp. 56, 58), C. H. HERTY, JR. stated that although slag control has become an integral and highly useful part of open-hearth activities from charge to tap, much has yet to be learned about slags and their effects on the metal.

For example, while the basicity of the slag is of great importance in the elimination of phosphorus and sulphur, next to nothing is really known about it. Use of the lime/silica ratio is general, but no one has yet determined how much active lime there is in an open-hearth slag. Lacking such information, slag control must still be classed as empirical.

Sulphur in the metal is lowered by increased basicity, fluidity and agitation of the slag and by high temperature. High iron oxide and increased sulphur in the charge (including sulphur absorbed from the fuel) make the attainment of a given sulphur content more difficult. Phosphorus in the metal is lowered by increased basicity and fluidity of the slag, a high FeO content of the slag, and by low temperatures. High phosphorus in the charge is an adverse factor to the production of low-phosphorus steel. Oxygen content before deoxidation is controlled by the carbon in the metal and the FeO content of the slag. Above about 0.10% carbon, the slag is of minor importance, but as the carbon falls below 0.10%, the importance of the slag increases.

Thus, the ultimate objectives of slag control should be to produce a slag in the furnace that will eliminate phosphorus and sulphur to the desired extent without excessive use of lime or excessive loss of iron as oxide; to conserve as far as possible both lime and deoxidizers; to prevent wastage of iron in the slag in producing grades which do not have strict phosphorus requirements and to reduce the melting period through use of as little limestone in the charge as possible. Another objective is to standardize the conditions of oxidation so that the deoxidizing additions will unfailingly produce the desired type of ingot.

Good approximations of slag compositions can be achieved by the trained eye of the melter or by rapid chemical analysis for FeO and silica. The consistency of the slag and the slag color remaining on the test spoon are other guides that have been used since the earliest days of steel melting. Appearance of the surface texture of slag cakes poured into standard molds is an interesting and useful indication. Slag viscosity has long been used by acid open-hearth men; for basic slags, viscosity is usually determined by the flow of slag in a tube developed by the author and his associates some years ago. Recently, new methods have been studied, but not yet commercially used for measuring slag composition rapidly. These include tests of magnetic characteristics, density, electrical conductivity, petrographic structure.

The practical application of a carefully "calibrated" empirical system of slag control in a modern steel plant is well illustrated by J. B. MALLOY ("Slag Control," *Steel*, Vol. 105, Dec. 25, 1939, pp. 48-51). Data on FeO content and corresponding lime/silica ratios for slag cakes of different external appearances are presented; the steel in question is quality low-carbon rimming steel for strip.

Slag cakes $4\frac{1}{2}$ in. in diam. and $\frac{3}{4}$ in. thick were used in the investigation. "FeO" in slags is, as usual, the total iron reported as FeO. The cakes are classified into 4 groups—wrinkled, furrowed, shiny black, and silvery—with 4 cakes in each. In the wrinkled type, FeO varied from 22-30% with lime/silica ratio equal to or less than 0.60, to 4-6% with lime/silica ratio of 1.00-1.20. In the furrowed type, FeO varied from 6-8% with lime/silica ratio of 1.25-1.50, to 10-12% with lime/silica ratio of 2.15. In the shiny black type, FeO varied from 12-14% with lime/silica ratio of 2.25, to 16-18% with lime/silica ratio of 2.45-2.65. In the silvery type, FeO varied from 18% with lime/silica ratio of 2.65-2.75, to 26% with lime/silica ratio of 2.90-3.10.

In preparing the charts, a detailed study was made of hundreds of heats produced under normal open-hearth practice, information being collected on FeO in slag, metal oxides in the bath, residual manganese recovery and aluminum addition. Averages of heats produced on individual furnaces during a month were plotted against the heats produced on every other furnace for the same heat and a general average obtained. This average was plotted against the results for succeeding months, the composite average being used in the accompanying graphs.

An extremely comprehensive discussion of the reactions that occur in basic open-hearth steel melting, comparisons of desirable and undesirable slag basicity practices and recommended procedures are given by F. M. WASHBURN & W. O. PHILBROOK of Wisconsin Steel Works ("Theory and Practice of Basic Open-Hearth Slag Control," *Iron Age*, Vol. 145, Feb. 22, 1940, pp. 21-25; Feb. 29, 1940, pp. 31-35; Mar. 7, 1940, pp. 58-62; Mar. 14, 1940, pp. 27-30). Any system of practical slag control must first provide for removal of phosphorus to a point below the desired maximum. The lime necessary to arrive at a desirable lime/silica ratio of 2.2-2.5 may be derived from the original charge, or a deficiency of lime may be charged and additions of burnt lime subsequently made. The procedure of charging a deficiency of lime has been practical only since the development of a rapid and reliable method, such as the "pancake" method, for estimating slag basicity.

Beyond this, the practices recommended may be summarized as follows: (1) Charge the lime as just indicated; (2) maintain a fluid slag (viscosity of 2-4 in. as measured by the Herty viscosimeter) within the 2.2-2.5 basicity range during the refining period by the use of fluorspar; (3) charge heats to melt somewhat above the desired carbon, and use hard ore as required to reduce the carbon rapidly. No ore should be added to quality heats during the last 2 hrs. before tapping; (4) thicken up the slag by adding burnt lime just prior to charging furnace deoxidizers, in order to decrease the rate of transfer of FeO to the bath.

The results of a statistical analysis of the relationship between slag and metal near the end of the basic open-hearth heat are presented by K. L. FETTERS & J. CHIPMAN of Mass. Inst. Tech. ("Slag-Metal Relationships in the Basic Open-Hearth Furnace," *Metals Tech.*, Vol. 7, Feb. 1940, 29 pp.) The study was confined to tests taken on an open bath prior to the addition of deoxidizers but not immediately after ore or other additions. Metal samples were obtained in the closed "bomb" type of mold, which affords the most consistent method in general use for determination of oxygen.

Data on 424 heats were contributed by 8 steel-producing companies, comprising a total of 650 samples, most of which were accompanied by simultaneous slag samples. Because of the large effect of carbon on many of the other variables, the data were broken down into 8 groups of nearly constant carbon content. The following factors increase with carbon content: $[C]\cdot[FeO]_M$; $[Mn]$; $(FeO)/[FeO]_M$; $(S)/[S]_M$ (the last at higher carbon only). The following decrease with increasing carbon: $[FeO]_M$, (FeO), (Fe_2O_3). The ratios $(Fe_2O_3)/(FeO)$ and $(MnO)/[Mn]\cdot(FeO)$ are substantially independent of carbon content. [The symbol [ ] refers to metal concentrations, and ( ) refers to slag concentrations.]

Within constant carbon-content groups a number of relationships were found of which the more prominent are: An increase in basicity is accompanied by increase in (FeO), (Fe_2O_3), $(Fe_2O_3)/(FeO)$, $(FeO)/[FeO]_M$, $(FeO)_{Total}/[FeO]_M$ and $(S)/[S]_M$. It is also attended by a decrease in the "Mn constant." Within the same carbon-content groups no significant relationship was found between residual manganese and FeO in the metal. There was no consistent relationship between $[Mn]$ and the distribution ratio $(FeO)/[FeO]_M$, although increased residual manganese was accompanied by decrease in the ratio $(FeO)_{Total}/[FeO]_M$.

To study the desulphurization ratio, 4

constant-basicity groups of low-carbon heats were considered. Within these the ratio $(S)/[S]_M$ increased with increased residual manganese, and to a lesser degree with an increase in the "Mn constant." The oxygen content of the bath could be estimated from the carbon content alone within a standard deviation of 19%. More elaborate methods for estimating carbon slightly improved the estimate. X (1a)

High-Test Cast Irons

A Composite

Last month, in a digest of trends in the use of castings *vs.* welded structures (METALS AND ALLOYS, Vol. 11, Mar. 1940, p. MA 148), we indicated the extent to which the improved mechanical properties of modern cast iron have contributed to its currently strong competitive position. The different metallurgical engineering practices employed to produce the wide range of high-test irons currently available, however, were not described. These have been discussed in several recent articles, and are reviewed herewith.

In general the methods used to produce high strength irons include employment of means for lowering of and accurate control of carbon content, the addition of alloys, the use of superheating (usually in an auxiliary electric furnace), the employment of ladle graphitizers or "inoculation," the use of special molding and casting technique, or the subsequent application of heat treatment. Following the classification of A. J. Nicol Smith ("Types of High-Duty Cast Irons," *Foundry Trade J.*, Vol. 62, Jan. 11, 1940, pp. 51-53) "high duty" irons should include not only high strength irons but also those with other exceptional properties, such as corrosion resistance or wear resistance.

The use of graphitizing additions to produce high-strength irons is widespread. According to E. M. Currie ("A Modern Cast Iron—Meehanite," *Metallurgia,* Vol. 21, Jan. 1940, pp. 63-66) an iron is melted (using considerable scrap steel) whose composition would give practically a white fracture when cast into the sectional thickness intended, and this is converted into a dense gray iron by means of a carefully-calculated ladle addition to the molten metal. Such practice gives unalloyed irons with as-cast tensile strengths as high as 55,000 lbs./in.^{2} Higher values can be obtained by combining ladle graphitization with alloying or heat treatment.

A. J. Nicol Smith states that the most important of the inoculating processes are those used for the production of Meehanite and Ni-Tensyl irons. The former are made with ladle additions of calcium silicide, while the latter are treated with nickel and ferro-silicon. Other inoculants are in use and have been developed recently [see, for example, "High Strength Cupola Iron," METALS AND ALLOYS, Vol. 11, Feb. 1940, p. MA 68]. The inoculation process, besides controlling the size of the graphite, also assists in its formation, and an inoculated iron is "grayer" than a material of similar composition not so treated.

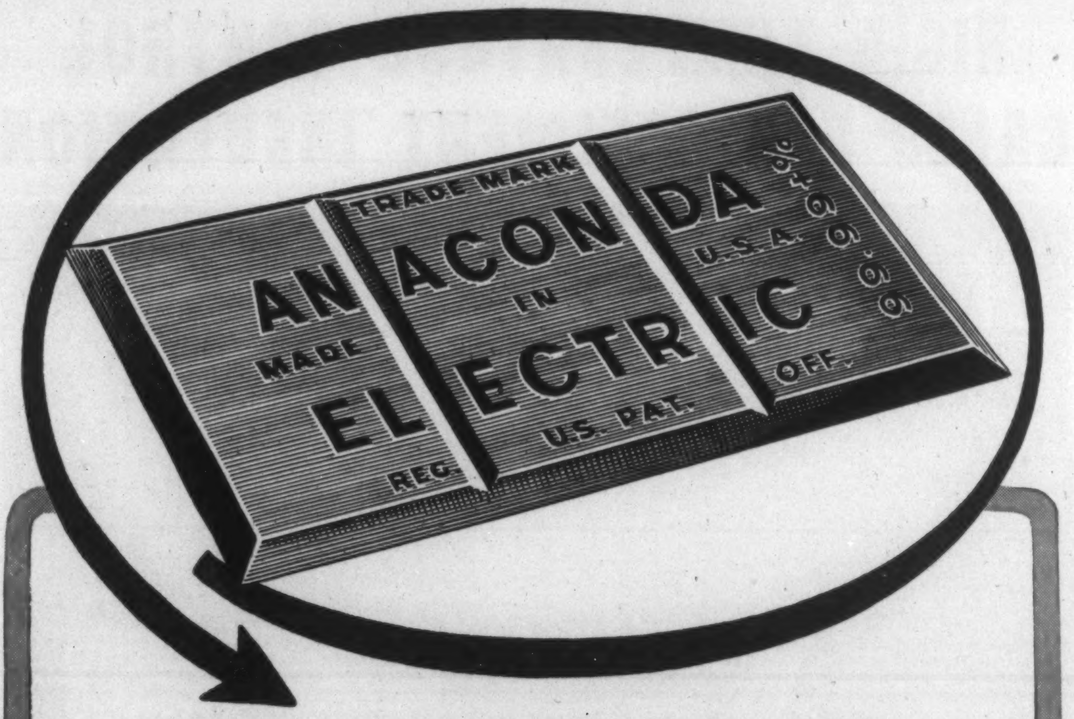
Currie claims that an essential structural difference between Meehanite and ordinary cast iron is the "secondary" [formed from carbide] nature of the graphite in the former as compared with the "primary" [formed from melt] nature of the graphite in the latter. This gives very fine graphite with stable carbides, and the resulting irons are remarkably strong and tough, highly machinable and not so subject to distortion if heat treated.

Another method of controlling the graphite, mentioned by Smith, is treatment of an iron containing about 0.2% titanium with carbon dioxide. By this method the transverse strength of a hematite iron, ordinarily around 40,000 lbs./in.^{2} can be raised to 75,000 lbs./in.^{2}

Moderately high-grade iron can be made in the cupola from a high steel mixture by melting quickly in a very hot furnace, according to P. Bardenheuer ("Schmelzbehandlung, Gefüge und Eigenschaften des grauen Gusseisens," *Giesserei,* Vol. 26, Nov. 3, 1939, pp. 543-549; Nov. 17, 1939, pp. 564-566). He also describes electric-furnace-melted irons, made from steel scrap and cast iron turnings [ratio not given], that were decarburized to 0.16% carbon, dephosphorized and desulphurized by two slags, recarburized, and treated with ferro-silicon. Such irons (3.05% C, 2.38 graphite, 1.66 Si, 0.34 Mn, 0.026 P and 0.008 S) are predominantly pearlitic with short, flaky graphite, hardness of 209 Brinell and tensile strength of 50,000 lbs./in.^{2}

The electric furnace is widely used for auxiliary heating of cupola melts, bringing about improvement in mechanical properties through reduction of carbon content. In hypoeutectic irons, however, such practice may be undesirable because of too great susceptibility to overheating, in which case the structure should be controlled through graphitizing additions to the ladle.

The applicability, with different practice, of some of the currently-used ladle additions is examined in an interesting article by E. Piwowarsky ("Beiträge zur Frage des Einflusses von Pfannenzusätzen auf die Eigenschaften von Gusseisen," *Giesserei,*



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Vol. 27, Jan. 26, 1940, pp. 21-30; Feb. 9, 1940, pp. 47-52). Specifically, experiments were made to determine just how improvement is effected by ladle additions, and in what irons improvement in mechanical properties through ladle additions was most pronounced. Also, cupola melts subsequently heated in the electric furnace and ladle-treated with calcium-silicon or ferro-silicon were compared with similar irons not subjected to ladle additions.

Ladle additions of ferro-silicon or calcium-silicon to electric-furnace-refined irons appeared to confer no benefits that could not be obtained by treatment with ferro-silicon in the furnace. Mechanical property tests showed that ladle additions to highly-carburized cast iron, melted from pig iron and cast iron turnings, function primarily as deoxidizers; they do produce a denser structure but have only a slight effect on mechanical properties. However the strongly graphitizing effect of these additions permits reduction in the silicon content of the iron, with corresponding decrease in "wall thickness sensitivity."

The practice of using larger proportions of steel scrap in the charge and carburizing in the furnace is much more effective, however, than ladle additions to highly carburized irons. Such high-steel mixtures can then be advantageously ladle-treated with calcium-silicon, ferro-silicon or titanium-silicon, in which case the analysis requires only a minimum of silicon.

Cast irons with carbon less than 2.8% and melted from high-steel charges are the ones most beneficially affected by graphitizing additions in the ladle. Quiet solidification of an iron well down on the hypoeutectic side results in a globular primary structure with pronouncedly eutectic graphite formation, owing probably to strong undercooling. Ladle additions reduce the undercooling effect and therefore the number of nuclei for primary graphite formation, and result in dendritic structures with irregularly disposed eutectic graphite. Reduction of the phosphorus content seemed to favor the formation of fine graphite.

The size and timing of ladle additions is vital to their efficacy, and immediate submersion appears to be essential to success. Special devices developed for this purpose can be employed, or the additions can be made as powders, or as pea-size pieces in the spout.

Many high-strength irons owe their superior properties to the addition of alloying elements. A broad review of such irons is given by P. A. Russell ("Alloy Cast Irons," *Proc. Staffordshire Iron & Steel Inst.*, Vol. 54, 1938-1939, pp. 72-75). The principal alloy is nickel—a graphitizer—which induces a finer graphite structure than does the most familiar graphitizer, silicon. About 3% nickel is usually alloyed with cast iron for irons designed to be hardened by oil quenching. With about 4% nickel the irons can be air-hardened, and with about 5% the irons are martensitic and permanently hard at normal temperatures. At about 10% nickel, cast iron becomes partly austenitic, and fully austenitic at about 17% nickel. Chromium has an effect opposite to that of nickel, and tends to form stable carbides. Silicon above 5% is regarded as an alloying element, as is manganese above about 2%. The latter is principally used to replace some of the nickel necessary to form austenite in certain forms of austenitic cast iron.

Austenitic irons of these types are also described by Smith (see above), who groups them in 4 classes: (1) 11% Ni and 5.5% Mn (Nomag); (2) 14% Ni, 7% Cu and 2-4% Cr (Ni-Resist); (3) 20% Ni, 5.5% Si and 2-4% Cr (Nicrosilal); and (4) special irons containing 35% Ni for low thermal expansion. Of importance primarily because of their corrosion resistance, such irons have higher tensile strengths, higher ductility, and better impact values than ordinary gray iron. X(1a)

1b. Non-Ferrous

Casting Magnesium Alloys

A Composite

Magnesium alloys, growing in application by leaps and bounds, are used most often as sand castings. As with every other cast metal, there are certain special precautions that must be observed in the production of best-quality castings; these are indicated in the first article abstracted herewith. The second article describes a melting technique claimed to improve the castability and mechanical properties of the sand-cast alloys.

The practice of Magnesium Fabricators, Inc., in producing magnesium alloy sand castings is described by A. H. Allen ("Molding and Casting Magnesium," *Steel*, Vol. 105, Dec. 25, 1939, pp. 36-38). The alloy ordinarily employed contains 6% Al, 3% Zn, 0.15% Mn and remainder Mg, and is supplied to the foundry in pigs, no further alloying being necessary.

Because molten magnesium has a high affinity for moisture, the green sand used in molding must contain not more than

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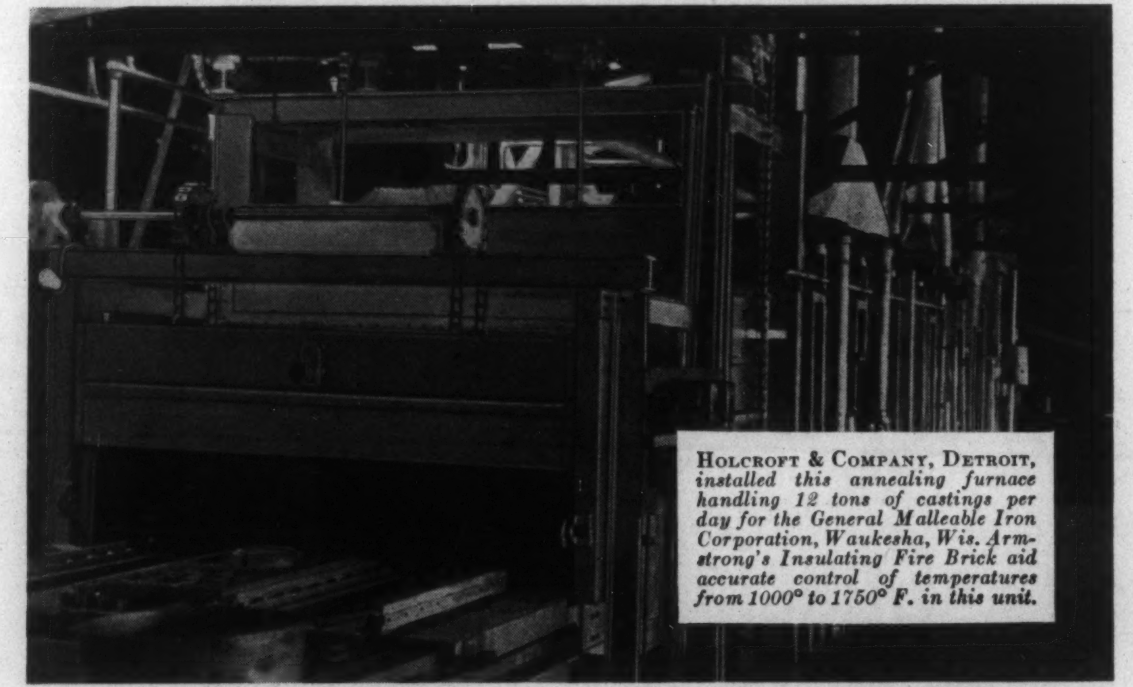

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2-2.5% moisture. As a further precaution, inhibitors are mixed with the sand to counteract the effect of what moisture is present. A mixture of sulphur, sulphuric acid, borax, and diethylene glycol is used with pure white silica sand. For molds, 3% by weight of bentonite bond is added, and in cores, using the same sand, an oil binder is employed. Cores are washed with a mixture of flake graphite, plumbago, and boric acid, and are baked in gas-fired ovens at 150° F. The sand is in a closed system.

Because of the light weight of magnesium, molds require deep copes with many risers. Gating is designed to obtain the maximum circulation of metal as it rushes into the mold. The metal usually is poured into a sand-lined wood pouring box from which it descends into a rectangular shaped sprue in the mold. On large castings, the weight of gates and risers is often 3 times the finished weight of the casting.

The metal is melted in oil-fired furnaces holding either 100 or 200-lb. pots formed of ⅜-in. boiler-plate; the average pot life is 50-60 heats. The charge comprises virgin magnesium alloy (pigs) and a portion of return scrap. After the pots are placed in the furnace, the temperature is brought up to 1700° F. in 45 min. and then reduced to 1550°-1600° F. for a short time before pouring. The molten metal must be kept covered to prevent oxidation. The pot is transferred to a ladle shank and carried to a mold. Then granular calcium is sprinkled on top of the molten magnesium as a further precaution against oxidation. The calcium burns slowly, thus protecting the magnesium. Just before tipping the ladle, the flux on top of the bath is skimmed back and a mixture of boric acid and sulphur is dusted over the pouring box. As the metal comes up in the risers, this mixture is dusted over the exposed surface. Flux that gets by the pot lip is held back by a steel wool strainer placed in the pouring box.

The castings are shaken out 15-30 min. after pouring. After sand-blasting, the gates and risers are sawed off on bandsaws, and the surface is carefully touched up with portable grinders and chisels, and by hand. Solution heat treatment, aging and surface finishing by a dip in hot sodium dichromate—nitric acid solution conclude the operations.

The foregoing melting practice, it will be noted, is based on heating the melt to temperatures several hundred degrees above the melting range of the alloy used. The actual effects of such superheating on the properties of the castings are investigated by K. Achenbach, H. A. Nipper & E. Piwowarsky ("Beiträge zur Frage der Schmelzführung von Magnesium-Gusslegierungen," *Giesserei,* Vol. 26, Dec. 15, 1939, pp. 597-604; Dec. 29, 1939, pp. 621-628). The fundamental purpose is to produce, through grain refinement, a uniform structural condition that will result in directionally uniform deformation properties. Simply adding aluminum and zinc greatly improves magnesium in this respect and the superheating is believed to offer further amelioration.

The effects of superheating on mechanical properties, solidification, grain structure and casting properties of alloys containing up to 7% aluminum and up to 3% zinc are studied. Strong superheating to 1500°-1650° F. produces a fine grain and a consequent improvement in mechanical properties; the undercooling occurring in primary crystallization is proportional to the previous degree of superheating. The mold-filling ability is increased 10% for the 7% aluminum alloy if the superheating temperature is increased from 1475° to 1650° F.; on the other hand a ternary alloy (6% Al, 3% Zn) was not appreciably affected. The shrinkage coefficients were reduced in both alloys by about 5% after strong superheating.

Hot shortness is considerably reduced in both alloys with increasing superheating temperature, the binary alloy showing the greater effect, because of its intrinsically finer grain. X (lb)

Cold-Rolling Copper Alloys

"PRODUCING COLD ROLLED STRIP AND SHEET." C. E. DAVIES. *Metal Ind., London,* Vol. 56, Jan. 26, 1940, pp. 103-106; Feb. 2, 1940, pp. 131-135. General survey of American and British practice.

In the last few years the design of non-ferrous rolling equipment has shown a tendency to become stabilized. The trend in America is toward automatic equipment and decrease in man power. The most notable tendency in Britain is the practice of hot rolling brass ingots. Most plants have adopted the practice of "scalping" after breakdown. Whether the metal is broken down hot or cold, further reduction is by cold rolling.

Automatic continuous gaging is rapidly gaining favor. With the modern high-speed mill, even allowing for the necessary higher first cost, the overall cost of rolling metal per ton is less than half that of the old inefficient slow-speed mill. Fortunately, without involving the heavy capital outlay of a strip-sheet installation, the recent modern practice of installing four-high mills for non-ferrous sheet production has proved most efficient and economical even for production of a varied range of sheet dimensions. The sheet blanks from the breakdown mill can be reduced rapidly in a single stand with a four-high mill.

The practice of finishing non-ferrous metal sheets in a four-high mill has, in the past, been thought to be unsatisfactory, but recent experience has shown that this is not the case, provided that either the rolls are changed, or that a separate mill is used for finishing, as the heavy work imposed on the rolls during the earlier reduction passes render them unsuitable for finishing high grade sheets. Alternate two-high mills may be employed for final finishing passes. RWB (1b)

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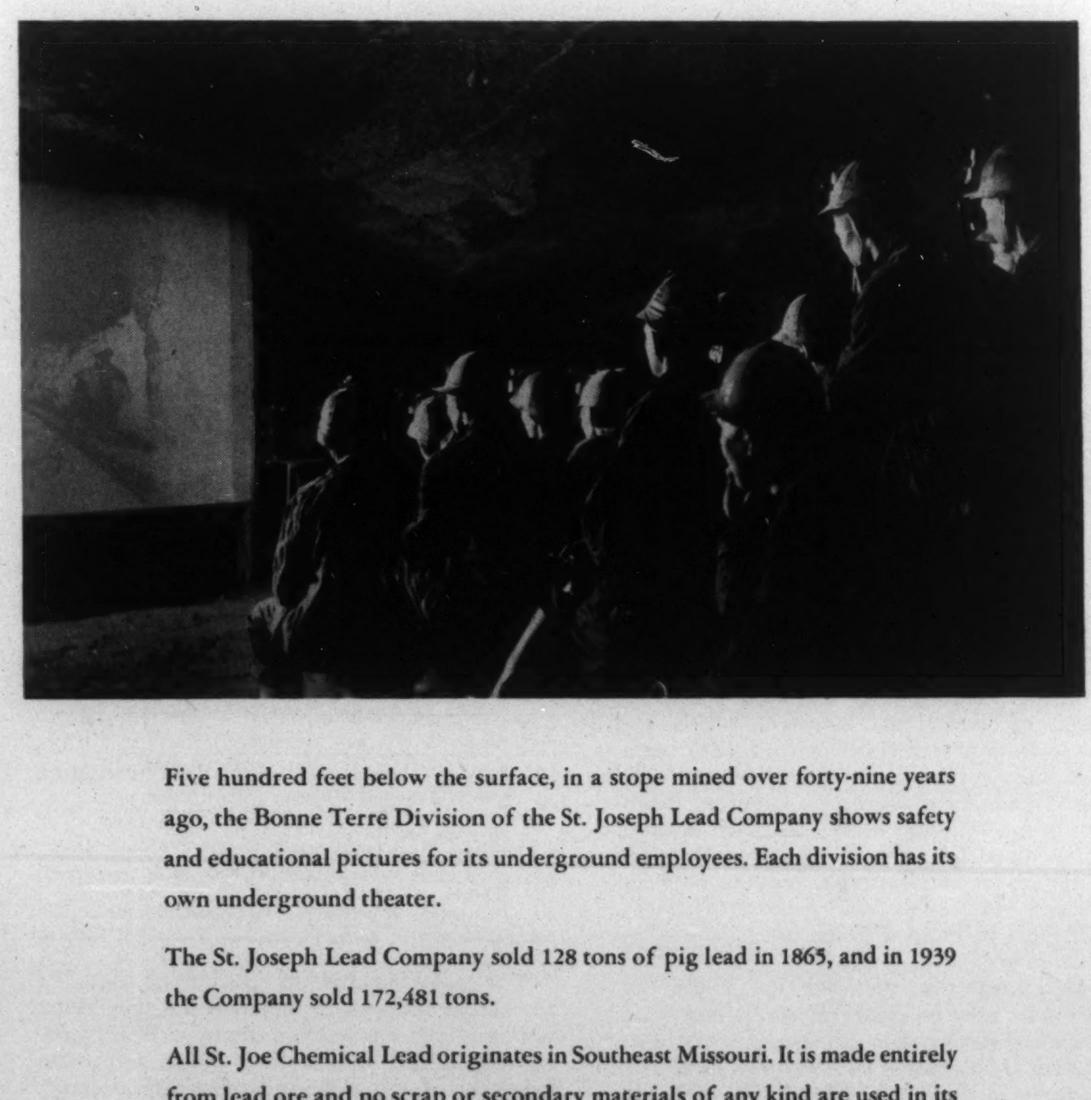

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Hardfacing

"Hard-Facing Technique." T. B. Jefferson (War Dept.) *Welding Engr.*, Vol. 24, Dec: 1939, pp. 37-39; Vol. 25, Jan. 1940, pp. 32-34. Review plus new data.

Hardfacing may be defined as a process of overlaying by welding a metal with high hardness characteristics on a metal of lesser hardness, so that surfaces that are normally subjected to the greatest wear will assume the characteristics of the harder metal.

Hardfacing materials may be classified in the following 3 groups: (1) ferrous alloys; (2) non-ferrous alloys; and (3) diamond-substitutes. The ferrous group is composed of welding rods for hardfacing having an iron base and alloyed with chromium, manganese, molybdenum, nickel, zirconium, boron or silicon. The materials of this group range in hardness from 415 to 650 Brinell. The non-ferrous alloys, also in the form of welding rods for hardfacing, are alloys of chromium, tungsten, cobalt and molybdenum, sometimes with a little iron. The diamond-substitute group is composed of the carbides of tungsten, tantalum, titanium or boron, and the borides of chromium. These materials are the hardest that are available for this purpose, ranging between 8.5 and 9.5 on the Moh scale of hardness, they must be bonded to the base material by some lower melting alloy.

Metallurgically, the deposits of the ferrous rods may be either of a martensitic or austenitic nature or a combination of both. Martensitic deposits will exhibit their full hardness in their initial deposited state; *i.e.* their hardness shows little or no increase upon cold working. The higher the hardness of a martensitic deposit the greater is its ability to resist abrasion, erosion, and galling, and the lower is its resistance to impact. Austenitic deposits are generally referred to as "self-hardening" in service. The deposits of the non-ferrous alloy hardfacing materials are like the martensitic ferrous, in that they also present their maximum hardness in the initial deposited state. The diamond substitute materials are deposited as matrix overlay, a deposit that is distinctly different from those previously mentioned.

In selecting a hardfacing material for the best results on a particular application, the accompanying table may be of value. In it the preferred material is at the left, with suitability decreasing toward the right. Obviously, the metallurgical characteristics of the materials available are fundamental to the art of hardfacing.

Deposit Required	Material Group Number				
Abrasion resistant	3b	3a	1b	2	1a
Corrosion resistant	2	1b	1a	3a	3b
Erosion resistant	3b	3a	1b	2	1a
Resistant to galling	3a	3b	2	1b	1a
Resistant to impact	1a	1b	2	3b	3a
Smooth	2	1a	1b	3b	3a
Hard	3b	3a	1b	2	1a
Thin	2	1b	1a	3b	3a

1a—Ferrous alloys containing less than 20% alloying elements.
1b—Ferrous alloys containing more than 20% alloying elements.
2—Non-ferrous alloys.
3a—Diamond substitutes in rod and powdered forms.
3b—Diamond substitutes in insert form.

The growing use of hardfacing has led to the question as to which welding process will produce the hardest deposit. The method of application has little effect upon the hardness of the diamond-substitute deposit. However, tests have shown that the different methods of application do result in a wide variation in the ultimate hardness of the ferrous alloy and non-ferrous alloy hardfacing materials. Two hardfacing rods of commercial manufacture, one from the ferrous group and the other from the non-ferrous group, were used in the tests. Standard blocks were hardfaced by the following methods: (1) metallic arc process (2) oxyacetylene process and (3) carbon arc process.

The specimens produced by the oxyacetylene process of welding were the hardest irrespective of the type of welding material or the temperature of the base. The average hardness of the specimen was increased 39 Brinell units by overlaying the hardfacing material on preheated metal. Next in hardness to the oxyacetylene specimens were those produced by the metallic arc process. With the ferrous alloy, deposits made on the "red hot" base metal were the hardest (601 Brinell). The specimens made by the carbon arc process were the poorest as regards hardness of deposit.

Certain definite conclusions can be drawn: Hardfacing materials deposited on surfaces that have been preheated will be harder than those made on cold base metal surfaces. Hardfacing deposits made by either the oxyacetylene or the metallic arc welding process will exhibit higher hardness properties than those made by the carbon arc process. The metallic arc process is most satisfactory from the standpoint of speed of deposition of metal. CEJ (2)

Resistance Welding Small Parts

"Some Applications of the Resistance Welding Process." C. L. Pfeiffer (Western Elec. Co.) *Welding J., N. Y.*, Vol. 19, Jan. 1940, pp. 14-19. Descriptive.

The control requirements for successful welding in the mass production of small parts can readily be mastered. Variations in the resistance of the weld area are of major importance and most difficult to control. The energy input for making the weld is I^2Rt; I is usually large, while R and t are small. Accuracy in timing can be held to within 1%, and very little change in I in the secondary circuit takes place with changes in contact resistance R.

Consideration must chiefly be given to the following items: (1) Nature of electrode material; (2) constant shape and area of electrode contact; (3) cleanliness of electrode contact area; (4) constant-temperature operation of electrode contact area; (5) uniformity for successive welds of the resistance of the contact area between electrode and the part being welded; (6) cleanliness of the material being welded; (7) uniformity and shape of the material being welded.

The most important and most special use of resistance welding is in the manufacture of small precious metal contacts of either the point or the disk type. The point contacts are about 0.030 in. high, with 0.030 in. diam. at base; the disks are 0.005 in. thick and about 0.090 in. in diam. Millions of such contacts go into electrical assemblies. Special care must be taken to have the contacting areas accurate in dimension because a difference of .005 in. represents a relatively large part of the total area. Using the hand-fed welding machines, 1000-1500 welded parts can be made per hr. replacing the former use of riveted contacts. Large savings in precious metal cost were possible because welding eliminates the metal used in the shank of the riveted contact.

A new contact material consists of a bimetal having one side of precious metal for contact purposes, and the other side for the purpose of welding to a spring or other shape required for assembly. The bimetal is manufactured in the form of tape, which is continuously welded at the rate of 8 ft./min., a separate weld being produced for each half-cycle of 60-cycle current supply.

An unusual application of butt welding is the welding of 0.011-in. diam. permalloy wire—performed under carbon tetrachloride to prevent formation of the brittle structure caused by welding in air. After welding, current is passed through wire for annealing. Small wires of nickel-chromium resistance and thermocouple alloys, perminvar and iron-constantan for thermocouples are joined on this machine. Other machines are used to weld bronze to "nickel silver" parts, or cobalt steel to permalloy. A hydromatic welder with 20 beads is used to weld small studs of less than 1/8 in. diam. to 0.060 steel strip, making 20 welds separately but in rapid succession. An electronic timer actuates ten heads connected to the transformer, within one cycle. The electrode tips are water-cooled and have made 4 million welds without replacement.

WB (2)

Cleaning and Degreasing

A Composite

With modern metal-working processes on one hand and metal-finishing operations on the other being made steadily more foolproof and automatic, it is only natural that the cleaning operation in-between should be carefully scrutinized by metallurgical engineers. Preparation for electroplating, the mechanism of degreasing and a new economical portable degreaser are the subjects of three recent articles on this general topic.

Various techniques and kinds of equipment may be employed in preparing metals for plating or other finishing operations, according to C. C. Hermann & R. W. Mitchell of Magnus Chem. Co. ("Cleaning Metals for Electroplating," *Iron Age,* Vol. 144, Dec. 7, 1939, pp. 45-48, 88). First of all, the surface to be plated must be chemically clean. The surface oils, greases and fats, as well as the dirt accumulations due to handling, must be removed. Oxide films such as rolling mill scale, fire scale, rust, tarnish, etc., must be removed. Cleansing materials that readily remove the first group are not adaptable to the removal of the second group, and the acids ordinarily used to remove the second group are not efficient on the first group. The process, therefore, involves two distinct cleaning operations: degreasing and descaling.

Some of the more important cleaning jobs for which degreasing is used are the removal of rolling and rust-proofing oils from sheet stock; the removal of stamping and cutting oils prior to bright dip or buffing; the removal of stamping, drawing and cutting compounds and of quenching oils prior to aqueous cleaning, electroplating, anodizing, or heat treating; and the removal of forming lubricants from preplated stock after stamping and forming.

A typical degreaser of the solvent vapor type (described) is equipped with a two-strand, cross rod conveyor with variable speed drive. Heat is supplied by steam coils to maintain the vapor at a temperature of 188° F. The work being conveyed through the machine is vapor-cleaned while passing over the dirty boiling liquid. The work then passes under pressure sprays of clean solvent slightly cooler than the vapor. The vapors are condensed on the work, due to the difference in temperature of the work and the vapor, to give a final cleaning.

Interesting innovations among solvent-vapor degreasers are the new portable units manufactured by the Phillips Mfg. Co., Chicago ("Portable Degreasers Cut Cleaning Costs as much as 60 Per Cent," *Steel,* Vol. 106, Mar. 11, 1940, pp. 51, 78). An ideal arrangement is to place the machined or processed part directly into the degreaser from the processing operation, a practice that is possible with portable degreasers. In this degreaser the solvent vaporizes at 250° F., and operating control is automatic. The high temperature of the solvent vapor is said to be particularly advantageous in removing difficultly-removable drawing compounds and in preventing steam smudge on bright work.

Much degreasing is also successfully done with aqueous solutions. Some of the factors involved in the use of hot, usually alkaline cleaners of this type are reviewed by H. G. Crowther ("Degreasing of Metal Parts," *Metal Ind., London,* Vol. 56, Jan. 12, 1940, pp. 23-25). A major function of the degreasant is to provide wetting power for subsequent plating. Additional substances must be used to impart this characteristic to the solution. Contaminants, on removal from the work, must be held or suspended in the solution in such a way that they will not be redeposited.

An essential function of the degreasant is the reduction of the interfacial tension to pave the way for breaking up the dirt particles for subsequent emulsification. The weaker the alkalinity the more efficient the emulsifying agents, while increasing hydroxyl-ion concentration tends to reduce the interfacial surface tension. Therefore the aim in formulating a detergent compound is to reconcile these two factors. Next in importance is deflocculation and the greatest efficiency will exist when the detergent compound is of a colloidal nature and introduces colloidal particles into the solution. The rinsability of a degreasing compound is important. Three aqueous degreasing systems are generally available: immersion for a given time in a hot degreasant; electrolytic cleaning; and treatment in automatic machines.

X (2)

2a. *Ferrous*

Activators for Carburizing

"WITHERITE IN CASE HARDENING." J. M. NOY & L. G. BLISS (Foote Mineral Co.) *Foote-Prints,* Vol. 12, Dec. 1939, pp. 15-26. Research.

Today, whatever the functional explanation offered, it is agreed that some activating agent should be present in carburizing compounds to facilitate the transfer of carbon to iron with the formation of iron carbide. As a class, the alkali and alkaline earth compounds are the most active energizers. Barium carbonate is the compound most generally used, as it is among the most energetic, and is abundant and inexpensive.

Witherite, a natural barium carbonate and the least expensive source of this compound, was investigated to determine methods by which its energizing activity could be improved. Specifically, the effect of particle size on energizing activity was studied. Examination of available literature had indicated various schools of thought on the role of barium carbonate as an energizer, but certain facts seemed beyond dispute: (1) the higher the carbon monoxide/carbon dioxide ratio in a gas reacting with iron, the greater is the percentage of carbon in the iron-carbon product; (2) barium carbonate either catalyzes the decomposition of charcoal to produce these gases or reacts with charcoal to form (among other things) carbon monoxide; and therefore (3) reduction in particle size should increase the activity of barium carbonate as an energizer.

In the tests pitch coke having 99.32% fixed carbon was the carburizer, and S. A. E. 1020 the steel carburized. The carefully cleaned specimens, 1/2 in. in diameter and 1 in. long, were heated to 1700° F. for 5 hrs. in contact with various mixtures (usually 20% energizer) of coke and barium carbonate; and then air-cooled in the retorts. The "activity" of a mixture was based on the gain in weight of specimens carburized therein; a commercial furnace was first used, but it was found that a more careful control than is obtained commercially was necessary to demonstrate the effects of slight changes in particle size. Laboratory equipment capable of very close control was therefore used for most of the tests.

The barium carbonate studied comprised three analyses variously ground; one of these was a "chemically prepared" material. This latter material, of extremely fine particle size, tended to ball when mixed with the coke. In the tests the chemically prepared energizer, with one of the smallest particle sizes and the highest purity, failed to equal the activity of a super-air-floated witherite, which repeated tests showed to be most energetic of all samples studied.

In general, diminution of the particle size of the barium carbonate was found to increase its activity as an energizer. The activity of each grade of barium carbonate is specific for a given particle size. Increasing the barium carbonate content of a carburizing compound improves activity, but not in proportion to the barium carbonate addition. Natural barium carbonate (witherite) probably contains a trace-element or elements that enhance its activity. FPP (2a)

Wire For Cold Heading

"A BRIEF RESUMÉ OF SPECIAL COLD HEADING WIRE REQUIREMENTS." A. M. REEDER (Jones & Laughlin Steel Corp.) *Wire & Wire Products,* Vol. 15, Feb. 1940, pp. 99-102, 130. Practical review.

The present status of cold heading practice, the materials available and the equipment employed are reviewed, and recent developments described. [This brings up to date the author's review abstracted in *Metals and Alloys,* Vol. 9, Mar. 1938, p. MA 152R2] One of the latest developments involves the use of rod rather than wire as raw material; the hot-rolled or heat-treated rod is reduced to the necessary round section by extrusion in the header die during the upsetting operation. The finish necessary for cold heading is advantageously obtained by the flash baker, which gives a very adherent lime coating for the extrusion operation.

The regular grades of steel from S.A.E. 1010 to 1040 will generally extrude without difficulty, assuming proper finish and correct mechanical setup. In general, plastic flow of the wire as drawn from hot-rolled rods is inversely proportional to its hardness. The plasticity of normalized or spheroidized wire appears to be considerably greater than that of the same material in the unnormalized or unspheroidized condition, but of equivalent hardness. Rimmed steel shows a definitely greater "plasticity" than killed steel of the same chemical analysis.

It was also observed that a lubricant at the point of contact of the hammer and the slug has a marked effect in increasing the effectiveness of the blow by reducing friction. Steels, however, that are ordinarily classed as free machining usually have somewhat poorer plastic properties, and may rupture prematurely when the metal is subjected to cold upsetting. This deterioration of plastic properties is most noticeable with high sulphur content. The effects of the design of a screw and the technique used in its manufacture are sometimes even greater in governing the driving strength than the physical properties of the wire from which the screw is produced.

Ha (2a)

Welding of Steels Containing Hydrogen, Arsenic, Titanium, etc.

"The Effect of Hydrogen, Arsenic, Titanium and Miscellaneous Elements on the Welding of Steel. A Review of the Literature to July 1, 1938." W. Spraragen & G. E. Claussen (Welding Research Comm.) *Welding J., N. Y.*, Vol. 19, Jan. 1940, Supplement pp. 24-30. Comprehensive review.

Up to 0.005% hydrogen has been found in mild steel welds made by oxyacetylene, atomic-hydrogen, and arc processes. The reducing and deoxidizing action of hydrogen has been found to affect the grain size of the weld metal and its behavior in the McQuaid-Ehn test. Good welds made with covered electrodes in mild steel 3/8 to 3/4 in. thick were of the deep-hardening type in McQuaid-Ehn tests if the welding atmosphere contained 10 to 90% hydrogen, remainder nitrogen, but were likely to be of the shallow-hardening type, if the hydrogen content was below 8%. Bare-electrode arc welds and oxyacetylene welds made with a reducing or oxidizing flame (neutral flame was not tested) were of the shallow-hardening type. Increase in the hydrogen content of chromium-molybdenum steels from 0.0001 to 0.0005 wt. % had no detectable effect on cracking in oxyacetylene welding.

In resistance butt welds in five steels containing 0.066-0.10% C, 0.00 Si, 0.47-0.59 Mn with 0.036-0.64 As, no effect could be ascribed to the arsenic. Tensile properties, notch impact value and sensitivity to cracking are not affected by 0.24% arsenic, but with 1.24% arsenic a steel may be particularly sensitive to welding cracks.

Titanium is used as a deoxidizer in steel refining and as an alloying element to form stable carbides and to prevent hardening of the heat-affected zone in arc welding. Titanium has been successfully used to prevent pick up of nitrogen and oxygen by weld metal.

Tin is generally undesirable in the welding of steel on account of the brittle tin-iron alloy formed. Zirconium improves the soundness of the weld metal, and is a promising agent for welding fluxes to combine with and flux nitrogen, oxygen and sulphur. Antimony is of possible significance in accelerating the deposition of an electrode. Zinc is generally undesirable in welding.

Cobalt steel with up to 35% cobalt can be atomic-hydrogen welded. Resistance welding was found to be difficult with a steel containing 6% cobalt. Boron is not successful as a deoxidizing addition in electrodes because it is lost during deposition in the arc. Iron containing 0.69% silver, or a little selenium, or 5% cadmium has been sucessfully welded by resistance methods. Steels with up to 1% magnesium can be welded without flux by the atomic hydrogen process. 54 references and some suggested research problems are included.

CEJ (2a)

Surface Treatment of Piston Rings

The Running-in of Piston Rings and Its Improvement by Surface Treatment ("Das Einlaufen von Kolbenringen und seine Verbesserung durch Oberflächenbehandlungsverfahren") C. Englisch. *Automobiltech. Z.*, Vol. 42, Dec. 1939, pp. 648-652. Review plus research.

Several methods are useful for the treatment of cast iron piston ring surfaces. For example, the running surface can be loosened by etching, so that easily soluble constituents are removed, forming pores which aid lubrication. Or, the surface may be oxidized, a practice that has a two-fold effect: The pearlite is decomposed with the formation of ferrite and temper carbon, and the oxide acts as a polishing agent. Oxidation can be achieved either by flame heating, or by furnace heating in water vapor, or anodically. Further, by diffusion of silicon into the surface at an elevated temperature, the outside layers are softened and graphitized.

Metallic coatings are also extensively used, *e.g.* cadmium, tin and lead. Tin-plating is often employed because of the good heat flow conditions associated therewith. Nonmetallic coatings are likewise often used to great advantage. The surface may be first subjected to corrosion and then the deposit put onto the loosened surface, such compounds as phosphide and sulfide being used. Lacquer coatings are also employed. Waterglass or synthetic resin is used as binder, with other materials optionally added to promote porosity or to aid running-in.

The experiments were carried out in an engine which was loaded with 80% of total capacity and run at top speed. The amount of gas passing between piston and cylinder was measured at intervals of 1/2 to 1 hr. The wear was determined as loss in weight of the rings. It was definitely established that the untreated ring required the longest time to reach the state of final gas tightness. The wear curve for the untreated ring is highest, probably because less abuse is suffered by the coated materials during the break-in period. There is not a great deal of difference between the three surface treatments tested, which were: Phosphide treatment and graphitized; artificial resin coating and graphitized; and tin-coating.

RPS (2a)

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Atomic Hydrogen Welding

A Composite

The atomic hydrogen arc method of welding metals is particularly valuable for jobs that cannot be handled with complete success by other methods, and which at the same time can bear the increased expense of welding by this process. Two articles have recently appeared that discuss various practical aspects of welding both ferrous and non-ferrous metals by the atomic hydrogen method.

The most useful applications of the method are given by W. E. Wilson of Gen. Electric Co. ("Atomic-Hydrogen Arc Welding Solves Difficult Problems," *Welding J., N. Y.*, Vol. 19, Jan. 1940, pp. 25-29) as the welding of hot short materials, highly-hardenable steels whose ductility must not be impaired, and overlays of hard-facing alloys. A general advantage of the method is that metal of the same analysis as the part being welded can be deposited. For this purpose the filler rod used in making the deposit should be of the same analysis as the part being welded, except that it should contain about 1/3 more carbon to compensate for the loss of this element. No appreciable change takes place in the other elements. Many manufacturers of alloys can furnish such filler rods. Ordinarily no flux is required.

With filler-rod and parent metal of identical analysis, the heat-treating properties of the deposited metal are the same as those of the die or other parts, a feature that assures uniform composition for reworking and thoroughly reliable service from the repaired die. In fact, it is usually impossible to detect the repair after the part has been machined and heat treated. In contrast, attempts to use hard-surfacing electrodes for die repair show that difficulties are encountered when it is necessary to anneal the die for reworking, as the deposit is not softened by the annealing temperature.

Again, atomic hydrogen produces an unusually smooth, ductile deposit free from pinholes or impurities such as oxides and nitrides. The weld is clean and free from scale and the work is not pitted by weld spatter. Undercutting is easily avoided. The thickness of the deposit can easily be varied from the thinnest surfacing to a heavy deposit. Feather edges can be built up without putting on excess metal. Definite savings are made by depositing exactly the amount of metal required, thus reducing machining costs. Small sections of cutting edges can be built-up without affecting adjacent areas by scaling, undercutting or spatter, so that reworking of the entire cutting edge can be avoided.

The atomic hydrogen arc is applied manually or in automatic welding machines not only for welding dies to be hardened but for building-up of composite dies by welding cutting or forming edges to a good grade of cast steel; changes and corrections in dies can be made because metal can be added where desired. Die casting dies have been repaired by placing just a spot of metal to cover a marred area and working it out smooth to a feather edge by playing the torch over the area. The advantage is in the absence of spatter or scale and the very little excess metal that must later be machined away. Permanent molds for plastics or rubber compounds are also successfully repaired.

Carbon steels with up to 1.25% carbon have been successfully welded by this means. Chromium steels with up to 40% chromium have been welded. If the chromium content is less than 20% the welds usually require no heat treatment, but higher-chromium steels must be heat treated to avoid brittleness. Special steels and most non-ferrous alloys are weldable. Alloys of the 15-20% chromium, 80-85% nickel type can be welded in the wrought or cast condition and the welds withstand the severe strains developed in this material when used as resistance heater elements. Brass with more than 40% zinc is practically unweldable because of vaporization of zinc; a flux is necessary when welding brasses with less than 40% zinc.

The equipment and technique used in applications of atomic hydrogen welding in the steel manufacturing industry are described by J. T. Catlett, also of Gen. Electric Co. ("Automatic Atomic Hydrogen Welding of Steel," *Iron & Steel Engr.*, Vol. 17, Jan. 1940, pp. 25-32). The process is explained, with special attention to hand welding and the variables controlled by the operator; single-arc automatic welding equipment and the methods used to control the variables; and the multiple-arc equipment and the methods of application to tube welding problems.

The use of dissociated ammonia as a substitute for hydrogen is discussed. Charts of welding data are developed for the single-arc, the 3-arc, the 6-arc, the 10-arc and the 15-arc equipment, giving welding speeds in ft. per hr. and in tons per hr. and welding costs per ft. and per ton using either hydrogen or dissociated ammonia. X (2a)

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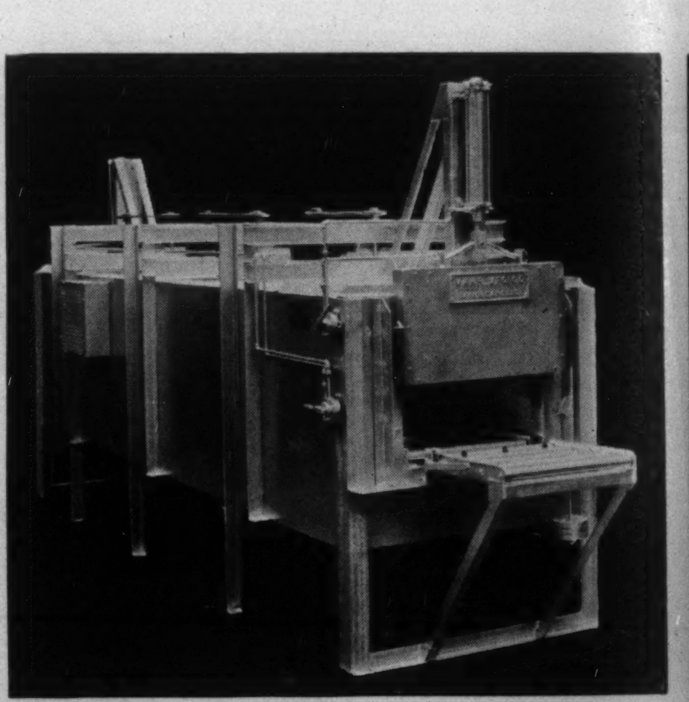

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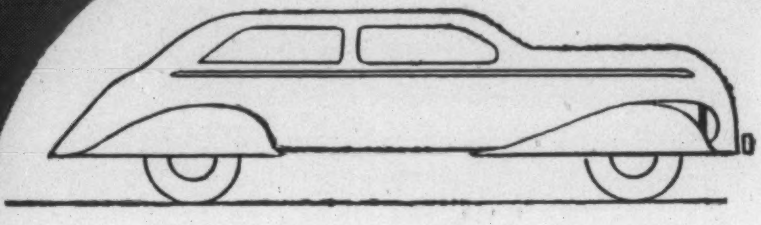

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AEROCASE and AEROCARB Compounds are saving money every day in production costs. These savings are a result of first, low cost of materials, second, low drag-out, third, speed with which these compounds impart a case to the steel, fourth, efficient use of the active chemicals by application of the two component principle.

Only a balanced bath operates at maximum efficiency: Both AEROCASE and AEROCARB are balanced by means of this two component principle, simply by making regular additions of a concentrated activator to a low cost bath material. The use of AEROCASE* or AEROCARB* Compounds imparts scientific control to Case Hardening and assures maximum efficiency.

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A. Activator	No. 28 Activator
B. Bath Material	No. 510 Bath Material

Cyanamid also offers: AERO Brand Case Hardening Compounds 30%, 40% and 75% as well as AEROIDS 96/98% Sodium Cyanide.

**AEROCASE and AEROCARB are trade marks of the American Cyanamid Company applied to Case Hardening and Carburizing Compounds of its manufacture.*

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AMERICAN CYANAMID & CHEMICAL CORPORATION

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Controlled Atmospheres

A Composite

The old method of heating steel in an open furnace where it would scale badly or decarburize deeply, then trying to correct by pickling and grinding is anything but satisfactory. Pickling is a nuisance and expense; decarburization means soft skin and therefore excessive grinding (when the decarburized area is accessible). Furnaces are needed that will heat steel without seriously altering the surface appearance or composition of the work being treated.

Our present position with respect to controlled atmospheres is very nicely reviewed by B. W. Gonser ("The Status of Prepared Atmospheres in the Heat Treatment of Steel," *Ind. Heating,* Vol. 6, Dec. 1939, pp. 1123-1134). The cheap, partly-burned fuel gases in use for the last 15 yrs. have been successful (when moisture is largely eliminated) for bright annealing low-carbon steel sheet strip and wire. For higher-carbon steels however, such atmospheres have been satisfactory only at low temperatures and with short heating periods; otherwise badly decarburized work is the result. Removal of practically all the water vapor gave little benefit, so attention was turned to other factors.

Really pure dry nitrogen would be excellent for steel treating, but commercial bottled nitrogen contains enough free oxygen, carbon dioxide or water to stain the work. Highly satisfactory inert gases can be prepared by the addition of a slight amount of a reducing gas, like hydrogen or carbon monoxide, to ordinary oxygen-contaminated nitrogen. Any tendency toward decarburization (because of the hydrogen) is readily corrected by addition of a mere trace of methane or natural gas.

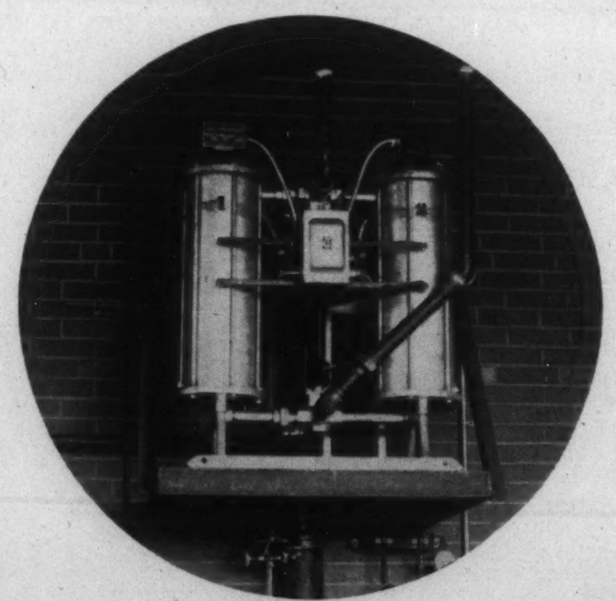
Pure hydrogen is decarburizing to most carbon steels at heat treating temperatures, particularly if moisture is present. Usually cracked ammonia is just as good and much cheaper. By partly burning the cracked gas (75 H_2/25 N_2) and removing the resultant water vapor, any hydrogen content below 75% can be obtained. Addition of methane will then decrease any decarburizing tendency of the dry gas. Cracked ammonia is unusually stable and uniform, and is successfully used commercially for heat treating materials like stainless steel that can stand a high-cost atmosphere.

Increasing in importance are the charcoal generator gases, formed by passing air through hot charcoal. The resultant gas is a mixture of carbon monoxide and nitrogen with some carbon dioxide, hydrogen and methane also present. The decarburizing effect of carbon dioxide is counteracted by the much higher proportion of carbon monoxide. The decarburizing effect of the hydrogen may be overcome by adding methane in amounts carefully determined for each job. Retort-heating of the charcoal before generating the atmosphere from it drives off the moisture and volatile matter, giving a substantially pure and commercially useful carbon monoxide-nitrogen gas mixture.

Getting back to the cheap, partly-burned fuel gases, these can be made to work over rather broad ranges if carbon dioxide, now recognized as the co-culprit with water vapor, is eliminated. The trend among manufacturers of furnaces for heat treating medium- and high-carbon steels is to supply atmosphere generators equipped to remove both moisture and carbon dioxide. This, in conjunction with controlled combustion of the fuel gas to keep the residual hydrogen and carbon monoxide low, gives a satisfactory protective gas for bright hardening.

There is a definite need in plants where prepared atmospheres cannot be used advantageously for an easily-removable effective coating that can be cheaply applied to a piece of work to protect it from the surrounding atmosphere — particularly where direct-fired furnaces are in use. Packing in cast iron borings, placing in externally-heated muffles or heating by radiant tubes are available methods of circumventing the use of a prepared atmosphere.

From the engineering point of view a scaled piece is generally less injured for service than a decarburized one, so when effort is made to avoid scale, care must be taken not to suffer the greater evil. This idea is echoed by A. Fisher ("The Influence of Controlled Furnace Atmospheres in the Heat Treatment of Steel," *Machinery (London),* Vol. 55, Jan. 4, 1940, pp. 355-360) in an article that pays particular attention to gases produced by passing air over hot charcoal. Fisher believes this type of atmosphere would not be very satisfactory were it not for the fact that it can be generated at high temperatures—thus giving a high carbon monoxide content— and then cooled quickly to the heat treating temperatures and used before the carbon dioxide can increase in accordance with equilibrium requirements. Charcoal generator gas can be highly satisfactory, but if circumstances are such that hydrogen and moisture are largely present,



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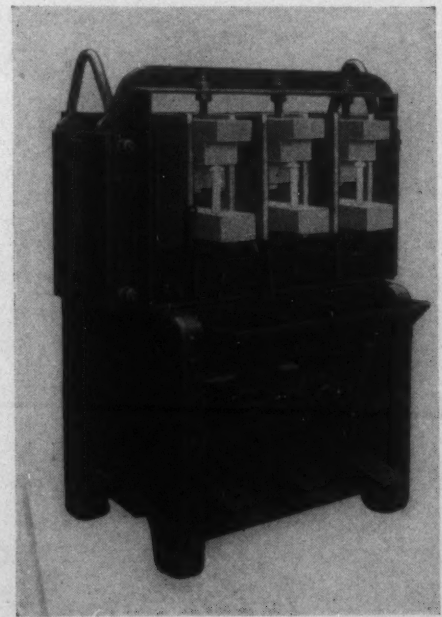

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the atmosphere can be more decarburizing than an open fire.

Credit to American engineers for most of our modern controlled atmospheres and equipment is given by W. Baukloh ("Glühen unter Schutzgas," *Korrosion u. Metallschutz,* Vol. 15, Nov./Dec. 1939, pp. 357-367) in a review of gases for annealing ferrous and non-ferrous metals. Protective gases for non-ferrous metals can contain more carbon dioxide than can those for steel, but the gases, generally speaking, should be as free as possible of sulphur. While for iron and steel, ordinary fuel gases are incompletely burned at 1500°-1650° F., the protective gas for non-ferrous metals should be produced at 2100°-2500° F. X (2a)

Sintering Alnico Magnets

"SINTERING OF ALNICO." G. H. HOWE (Gen. Electric Co.) *Iron Age,* Vol. 145, Jan. 11, 1940, pp. 27-31. Descriptive.

Alnico, the permanent magnet alloy which in recent years has enjoyed a rapidly increasing commercial acceptance, has always been cast to shape. Because of the hardness of the alloy any finishing or machining operations have been most difficult. Now, however, Alnico is being sintered to shape, with dimensions held to very close limits. The application of powder metallurgy to the making of Alnico magnets broadens the field of magnet application since it permits the production of magnets too small and intricate to be cast satisfactorily and economically.

Alnico contains from 9 to 13% aluminum in addition to nickel, cobalt, copper and iron. But for the aluminum sintering might be a simple matter; aluminum has such great affinity for oxygen that it is readily converted to an inert oxide, not reducible by the hydrogen atmosphere used in sintering. When particles of aluminum become oxidized they are not free to enter into alloy combinations with other elements. The idea that aluminum dissolved in one of the other Alnico constituents would be less subject to oxidizing influences led to trying several alloys, the most practical of which was 50% ferro-aluminum, which is very brittle and readily disintegrates into a fine powder. Combination of this alloy powder with others by powder metallurgy methods produced the first sintered magnet with properties like those of cast Alnico.

One fact that became evident in the early stages of the development of sintered Alnico was that a large amount of pure dry hydrogen was necessary. This is prepared by removing the oxygen from the hydrogen by passing the latter over hot copper. The copper converts the oxygen into water, which is absorbed by drying agents. No matter how pure the hydrogen may be made, the purity is of little advantage if it is not carefully maintained, so the gas must be kept and used in protected enclosures.

To facilitate sintering and to make it commercially feasible, a furnace was devised through which pressed magnet preforms could be fed continuously. This was necessary because the sintering temperature is close to the melting point of the alloy. By passing the work continuously through a furnace, the effect of any temperature gradients in the hot zone is nullified because each magnet, regardless of position on a boat, passes through the entire length of the hot zone and all magnets receive exactly the same sintering treatment.

At the sintering temperature of the alloy, surfaces in a hydrogen reducing atmosphere are in an ideal condition for sticking together. A boat with a greatly reduced tendency to stick at high temperature in hydrogen was made by pressing composite slabs from high purity iron powder and iron powder containing alumina, the latter forming he welding-resistant surface. After sintering in hydrogen of ordinary purity, these slabs were fabricated into boats by welding on the straight iron sides. End pieces against which pushing is done were cut from sintered slabs and welded on so abutting surfaces are faced with the protected side. Another useful type of boat is made completely of an iron-alumina mixture which may be pressed thick enough so that the middle can be machined out to form a shallow box.

With the exception of the ferro-aluminum, the other constituents of Alnico are purchased as manufactured powders. Most sintered magnets are small in size and can be formed economically and well in tablet making machines. The magnet preforms pressed on these machines are loaded on boats and fed into a continuous furnace for progress through the hot zone and into the extension for controlled cooling. Alnico is not readily machinable in the final sintered condition. In the "as pressed" condition it is too fragile for machining, but strong enough for ordinary handling.

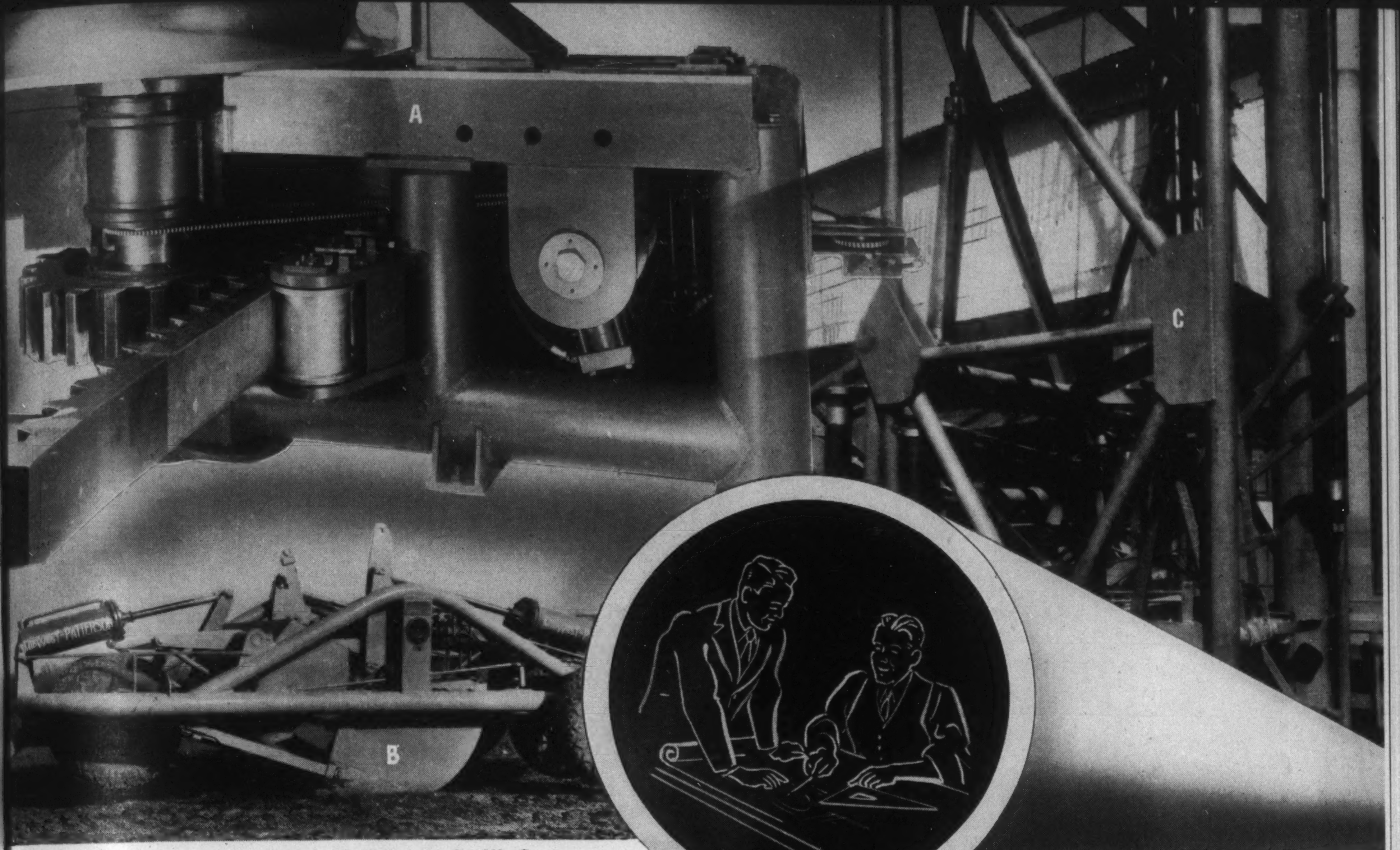
On the other hand partly-sintered bars are machinable, and for making samples or experimental specimens, pressed bars are partially sintered in hydrogen, then machined to shape, then completely sintered. Parts shaped in this way are just as good magnetically after the final sintering as the parts sintered in the regular way.

The material cost for sintered Alnico at present is greater than that for the cast product. Some of this difference is undoubtedly made up by the elimination of the scrap loss which occurs in the casting process. However, other economies are desirable to make the cost of sintered magnets more attractive. A big step in this direction has been accomplished by controlling the cooling rate of the magnets so that they cool at a rate which gives the optimum magnetic quality.

Proper cooling is desirable as subsequent magnetic quality depends largely upon the state of dispersion of the intermetallic compound NiAl. An additional aid in this direction is obtained by making a modification in composition. The incorporation of final heat treatment in the sintering furnace operation leaves only pole face grinding, magnetizing and checking to be done. The latter two operations are now being done automatically in one large scale application. At the present stage of development, the economics in general seems to be in favor of the sintered product over the cast for magnets weighing 0.1 lb. or less.

The sintered magnets are fine-grained and, therefore, have a much higher physical strength than the cast product (5 to 9 times greater respectively in transverse and tensile, tests). The same permanent magnet quality of cast Alnico is present in the sintered product. This includes the highest amount of stored energy per unit volume of any permanet magnet material produced commercially today and high resistance to demagnetization caused by stray fields, vibration and heating.

The extent to which the sintering process will replace casting for the manufacture of Alnico will depend on future metal powder costs, further technical simplification and improvements in processing as a result of production experience. VSP (2a)



Courtesy: (A) Wallace Supplies Mfg. Co., (B) Midwest Piping & Supply Co., (C) Franks Mfg. Co.

THEY'RE PIPING AWAY THE TWIST & SAG

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Engineers have long recognized that tubular members are exceptionally rigid—ideal for machine frames. Now, welding makes this construction possible. Example:

Effective use of rigid tubular members for the frame of the Wallace Supplies pipe-bending machine shown in (A) yielded the following benefits as compared to the former welded frame using structural shapes:

23% reduction in set-up time
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10% reduction in weight
Deflection reduced from .103 to .013 inch
Torque capacity increased from 7,000,000 to 13,000,000 inch pounds

By minimizing twist and sag, tubular construction is also improving earth-moving scrapers (B), portable derricks (C), furniture, aircraft, and hundreds of other new products and structures. And, there are any number of other shapes* which can be fabricated by welding into rigid, light-weight designs for improved performance, greater sales volume and lower costs.

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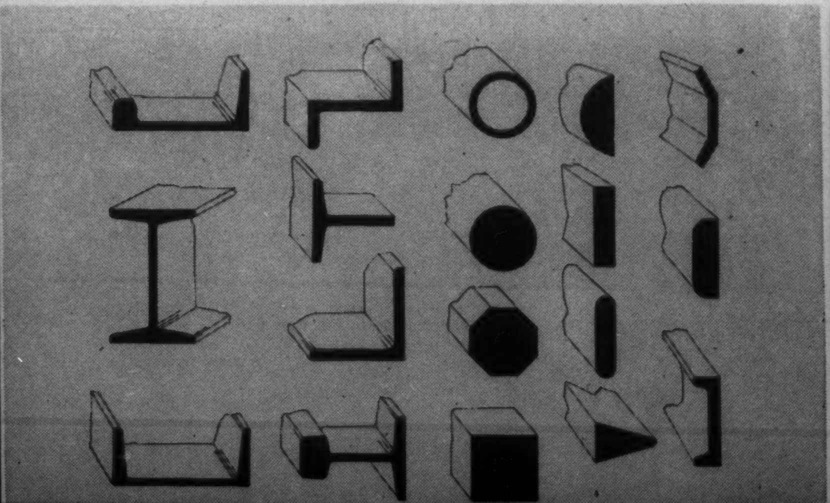
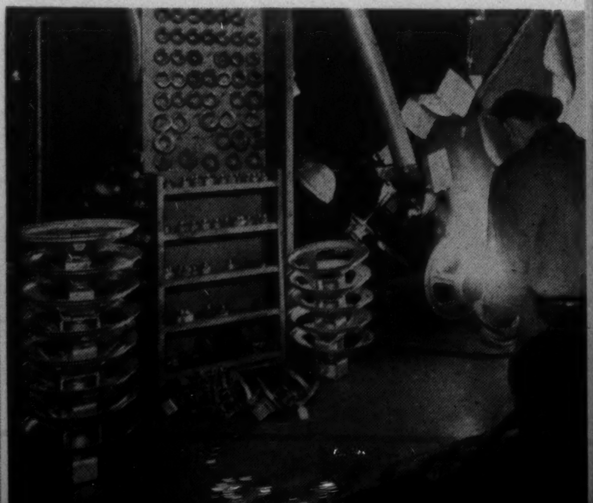


SAVES 66% TIME. Here, arc welding with a *"Shield-Arc Jr."* and "Stainweld A" Electrodes replaces method of attaching steel plates to loudspeaker magnet (Permang) by brass screws. Saves 66% in time and gives better performance. Courtesy Jensen Radio Mfg. Co., Chicago, Ill.



Superfinishing

A Composite

The development of "superfinish" began in 1935 with investigation of the "Brinelling" of wheel bearings of automobiles shipped by freight to the Pacific Coast. This was eliminated by removing the tiny irregularities on the surface, and the method finally developed (by Chrysler engineers) to do this on a production basis was the Superfinish process, by which remarkably smooth surfaces with irregularities measurable only in micro-inches can be obtained. Recent articles have reported on the metallurgical nature of superfinished surfaces, on a new development in surface analyzers, and on mechanical equipment for performing the operation.

Superfinished surfaces have none of the characteristic irregularities of turned, ground, sanded, burnished or honed surfaces, according to D. A. Wallace of Chrysler Corp. ("Superfinish," *S.A.E. Journal*, Vol. 46, Feb. 1940, Trans. pp. 69-92). An excellent test for surface roughness is to wipe carefully the bearing surface and babbitt bearing to be used against it free of oil and see that the babbitt has not been scratched in any way. The babbitt bearing is held against the bearing surface and a slight pressure is exerted while moving it back and forth 15-20 times. Any surface other than a superfinished surface will produce pronounced scratches in the babbitt. Basically, superfinishing consists of a combination of short motions, light abrasive pressures, slow abrasive cutting speeds, hard abrasive stones and a lubricant of suitable viscosity.

In superfinishing, the tool used is a bonded abrasive in which relatively coarse grits are imbedded firmly. The abrasive blocks are always of such area that once a grit has done its cutting it is washed away, and are made up in sizes and shapes necessary to fit the work. The block generally oscillates 1/16 in. at 1,000 r.p.m. The abrasive pressure used is low, but actually represents a large pressure on the relatively minute areas of true contact with the peaks and projections. For this reason rough work can be superfinished in the same time as smoother surface, and stones require dressing only in exceptional cases. Material, preparatory surface and surface desired determine r.p.m. of work, which is relatively low compared with other methods.

Because of low surface temperature developed, no coolant is necessary. However, a fluid is used to wash away the chips produced and the worn-off abrasive. At the end of the superfinishing process the fluid has sufficient viscosity to balance pressures between work and abrasive, acting as a lubricant. This permits accurate control of surfaces. When this stage is reached, no additional change in work-surface characteristics will be made, regardless of how much longer the operation is continued. No production superfinishing operation requires over 50 sec. The amount of material removed is only 0.0001-0.0002 in.

In conventional surface finishing methods, the heat produced softens the grain boundary material holding the crystalline grains in place to such an extent that the grains are jerked out readily from their setting. This pulling out, crushing and distortion of the grains results in a surface made up of irregular fragmented material. The grain boundary material may be softened to such an extent that it flows over the surface filling up the minute cracks and lying across the crystalline structure. Under severe conditions of use, this smeared material flakes off and, as it is harder than the metal of the crystalline grains at normal temperature, acts as an abrasive, causing rapid wear. In superfinishing, on the other hand, the heat produced is insufficient to change normal conditions. Therefore, hard crystals, being held solidly in place by harder grain boundary network, are cut cleanly. This results in smooth surfaces consisting largely of metal in the unworked condition.

Electron diffraction investigation indicates that the top layers of fine-ground, lapped, and superfinished surfaces that have been carefully cleaned and degreased are layers of adsorbed gas 2-3 A.U. thick. The second layer of the fine-ground surface is 20-80 A.U. thick and consists of comparatively loose fragments of oxides, nitrides and decarburized metal. The third layer, about 50,000 A.U. thick, is made up of crystals badly strained by enormous pressures and of areas of undissolved carbides produced by high temperatures [?] and is very brittle. Below this layer is the undisturbed bulk metal. The second layer of a lapped surface is about 30 A.U. thick and consists of abrasives, oxides, dust, etc. The third layer, about 15,000 A.U. thick, is of deformed crystals strained by excessive pressures. Below this is undisturbed bulk metal.

The second layer of a superfinished surface is about 15 A.U. thick and consists of oxides and dust, with absolutely no trapped abrasive. The third layer, about 15,000 A.U. thick, consists of only deformed crystals with no evidence of excessive heat. Below this is the undisturbed bulk metal.

Superfinish results in reduced friction and thinner film lubrication. Tests of oil-film strength *vs.* surface smoothness, using an S.A.E. oil-testing-machine, indicated that

What's What

in

Temperature Control

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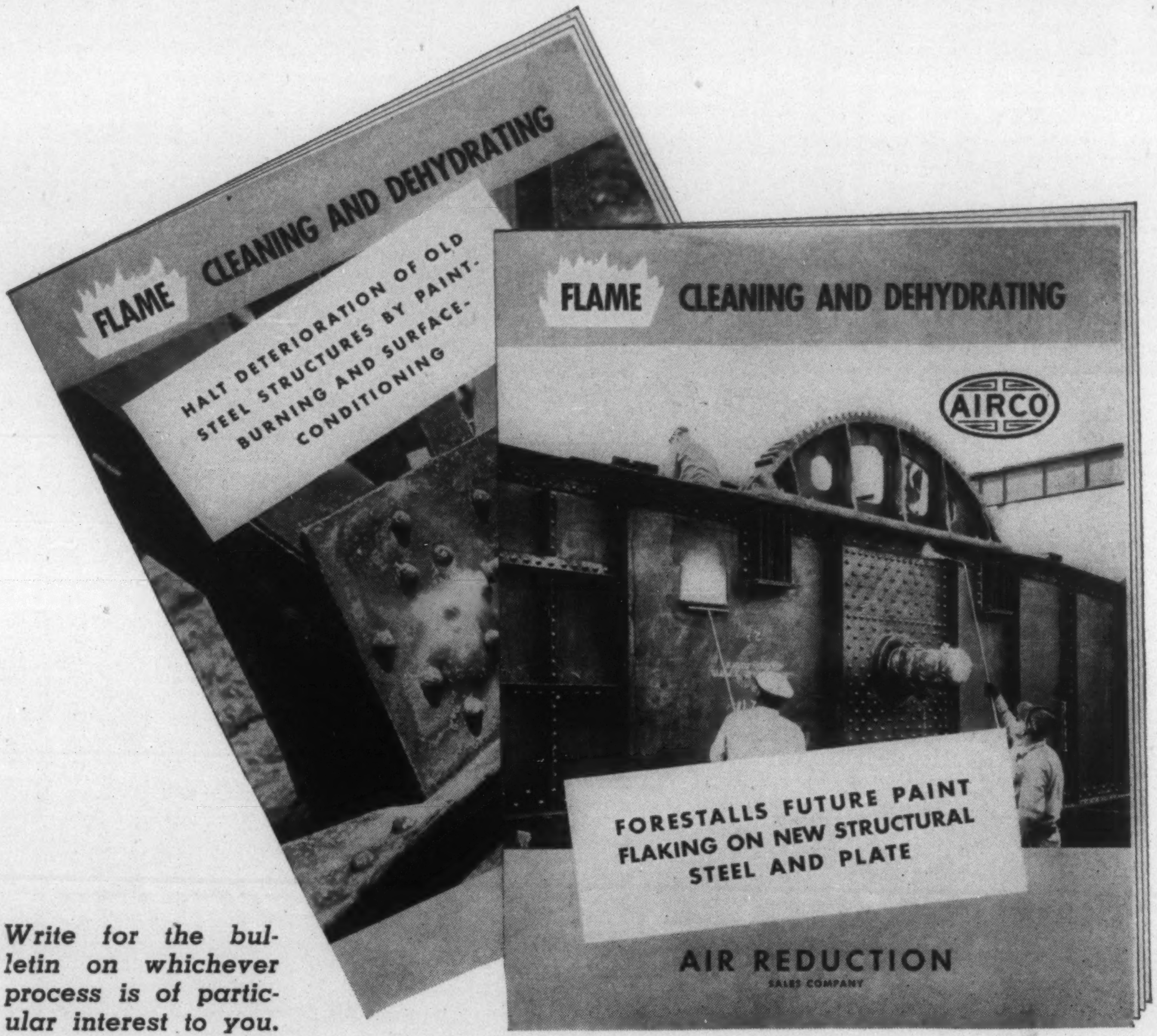
It is easy to reason why this system permits the closest control possible under any method, when it is realized that there are no parts to be set in motion before control can be effected, nor parts to wear, stick or otherwise interfere with control accuracy.

Complete detailed information on the "Radio Principle" Electronic Control System may be had by writing to the Wheelco Instruments Company, 1933 South Halsted Street, Chicago, Illinois.

Two INTERESTING BOOKLETS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superfinished surfaces had twice the bearing capacity of ground surfaces. Wear tests, using the same machine, showed that a babbitt bearing lost 46.5% more weight with a ground surface than with a superfinished surface. Other advantages of superfinish are maintenance of initial clearances, quiet operation and long life of products.

According to Wallace, none of the various methods available for measuring surface smoothness—touch, visual, microscopic, photomicrograph of profile, profilograph, profilometer, X-ray diffraction or electron diffraction—are universally applicable, and much remains to be done in this field. What may be a long step forward in this direction is a new instrument designed by Brush Development Co. ("Surface Profiles in Microinches," *Iron Age*, Feb. 15, 1940, pp. 32-33) to give *absolute* records of surface *contour* rather than *averages* of the sizes of *defects*.

The measuring method most widely used at present gives meter readings representing continuous running averages of the heights and depths of surface irregularities. The new instrument, on the other hand, is an analyzer, and provides topographic charts of the surfaces of finished parts. Magnification up to 100,000 times permits the making of satisfactory records of surface irregularities smaller than one millionth of an inch. The instrument itself (described in detail) consists of a surface analyzer head mounted on an adjustable stand, a calibrating amplifier and a direct-inking oscillograph.

Superfinishing machines specially designed for various types and shapes of work are commercially available, and some are described by L. D. Tyson of Foster Machine Co. ("Superfinishing Requires Complex Motions," *Machine Design*, Vol. 12, Feb. 1940, pp. 33-36). A general purpose machine must be designed to take a variety of parts and to provide for readily obtaining whatever combinations of motions are required. The high production machine described is used for superfinishing external cylindrical surfaces on shafts, pins, pistons or other parts within the range of 3-4 in. diameter and up to 6 in. long. X (2a)

Flame-Hardening Converted Rolls

"Converting Worn Rolls." W. F. Lautner (Air Reduction Sales Co.) *Steel*, Vol. 105, Dec. 25, 1939, pp. 42, 44. Practical.

A worn 18-in. diam. work roll from a skin-pass mill was annealed and then turned down to tension roll size, which is 16 in. in diam. The working surface, which is 3.5 ft., was then flame-hardened with a tip 4 in. wide. Eleven passes around the circumference of the roll were made, requiring 2 hrs. The rolls are 0.85% carbon and have a scleroscope surface hardness of 30 after annealing, which was raised to 95 by flame-hardening. This and other rolls so treated performed very satisfactorily as tension rolls. A saving of at least 75% of the cost of a new roll is obtained.

Every precaution was taken to keep the roll cool during the entire surface-hardening process, so as to prevent surface checks and cracking of the roll in service. The cooling produced by a water jet built into the torch tip was supplemented by additional water-cooling from a jacket built around each side of the tip in the form of a square made of ¼-in. drilled pipe. The roll itself was immersed to half its diameter in a water-bosh fabricated on the lathe bed by welding 1/16-in. plate around the roll's half-diameter with proper clearance for the neck. The bosh was supplied with running water as the roll turned in the lathe during hardening.

When the work roll is turned down, it is bored out for fitting the necks in the ends. The bore is 0.012 in. smaller in diameter than the outside of the neck fit. The necks are packed for 18 hrs. in dry ice, reducing the diameter an average of 0.0015 in. per in. of neck diameter. The frost formed on the neck surface after its removal from the dry ice is wiped off with a cloth saturated with wood alcohol. The bore is coated lightly with a mixture of white lead and oil. These precautions are necessary as otherwise the two parts will not go together regardless of the pressure applied. When properly prepared, the necks are pressed into place under a pressure of 60-80 tons. Flame-hardening is done after the necks are press fitted.

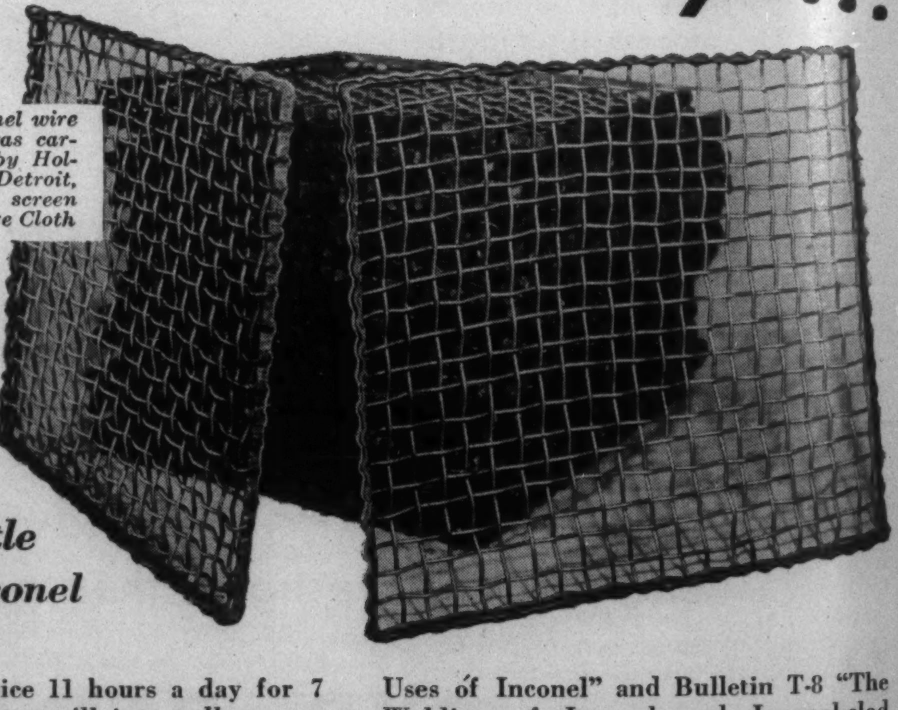
Pinch rolls are made from S.A.E. 1045 steel, subsequently flame-hardened for desired surface hardness. These rolls have 44 in. face and 10 in. diam. The saving obtained on these rolls is $600 on a set of two. MS (2a)

Grinding Cracks in Quenched Steels

"Some Problems on Quenched Steels. Part I—On the Cracks of Quenched Steel." Kaizo Monma. *Sci. Repts. Tohoku Imp. Univ.*, Vol. 28, Oct. 1939, [actually published in Jan. 1940] pp. 128-142. Original research.

The cause and prevention of the tiny hair-like cracks that sometimes form in

New Type Heat Treating Trays...



Part of a lot of 160 Inconel wire screen trays used in a gas carburizing furnace. Made by Holcroft and Company, Detroit, Mich., of Inconel wire screen produced by Michigan Wire Cloth Company.

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Intense heat and rapid cooling have little effect on strength and toughness of Inconel

Long, economical service from lightweight trays made of *wire?* Yes...that's what you get when the wire is INCONEL. For example:

The trays illustrated are used for heat treating farm machinery parts at a temperature of 1675°F. They are 15¾" x 14¼" x ¾" deep, made of ⅛" diameter, 1" mesh Inconel wire screen...edges turned up and welded to Inconel strip.

Though used to replace a much heavier type, these Inconel wire trays have seen continuous service 11 hours a day for 7 months... *and are still in excellent condition.*

Inconel resists carburization and retains its strength at high temperatures. Furthermore, this tough, heat-resistant alloy is *readily available in various forms, and is easily formed and welded.* So in Inconel you have an ideal material for a wide variety of heat treating equipment.

For detailed information on Inconel write for Bulletin T-7 "Properties and Uses of Inconel" and Bulletin T-8 "The Welding of Inconel and Inconel-clad Steel." Address:

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INCONEL

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Whitey Sez:

QUOTE—

"I trust a good deal to common fame, as we all must. If a man has good corn, or wood, or boards, or pigs to sell, or can make better chairs or knives, crucibles (*) or church organs than anybody else, you will find a broad, hard beaten road to his house, though it be in the woods."

—EDWARD WALDO EMERSON

* *AND STAINLESS ELECTRODES*

MAURATH, INC., CLEVELAND

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hardened steels during grinding are sought. Specimens of 0.9% carbon Swedish steel 0.2 x 1.2 x 2 in. were hardened by water quenching, and were tempered for 30 min. in an oil bath at different temperatures. The specimens thus hardened and tempered were ground to a depth of about 0.02 in. on one-half of one flat side. After grinding, the specimens were slowly heated to 1475° F. in vacuum and slowly cooled. Then the other half of the surface was ground. The surface that was ground after annealing showed no grinding cracks, but only quenching cracks. Therefore, in each specimen a distinction could be made between grinding cracks and quenching cracks.

It was found that only those specimens that were tempered below about 300° F. showed grinding cracks. This was explained on the basis of the volume change of the $\alpha \rightarrow \beta$ martensite transformation. The surface being ground is heated locally, hot enough to transform α martensite into β martensite of greater density than α. Since the core remains α martensite, there is a severe stress set up at the junction between the two forms of martensite. This local stress is sufficient to cause the grinding cracks. On the other hand, if the tempering temperature is over 300° F., the whole specimen is transformed into β martensite, hence grinding in this case causes no transformation and therefore sets up no surface stresses.

High speed steels were not subject to grinding cracks, but did show cracks after tempering. Experiments were therefore carried out on such cracks in high speed steel, using specimens of the following composition: 0.56% C, 19.7% W, 4.6% Cr, 7.1% Co and 1.27% V. The specimens were quenched from 2375° F. in oil and were tempered for 30 min. at various temperatures up to 1650° F.; in some cases, the specimens were hot-quenched into baths held at 930°, 1020° and 1110° F.

It was found that in specimens ground off to remove the decarburized zone, tempering cracks did not appear, but in other specimens, cracks appeared when tempering in the range from about 1020° to 1200° F. Tempering at higher or lower temperatures did not result in the formation of cracks. The cracks are apparently formed by a differential volume change between the decarburized case and the unchanged core. The core material suffers partial decomposition of austenite to martensite during tempering, with consequent expansion. On the other hand, the carbon content of the decarburized case is so low that it is not subject to the austenite-martensite transformation. Hence, as in the case of the carbon steel, the high speed steel is subject to stresses set up at the surface, but the cause of the stresses in the two cases is not the same.

This view was corroborated by dilatometric studies of specimens corresponding to the core and case compositions. Tempering above 1200° F. does not cause cracking, because of the enhanced plasticity of the steel at these higher temperatures. If the specimen is surface-ground before tempering, no cracks are likely to develop because there is no decarburized case to expand or contract at a different rate than the core.

AUS (2a)

2b. Non-Ferrous

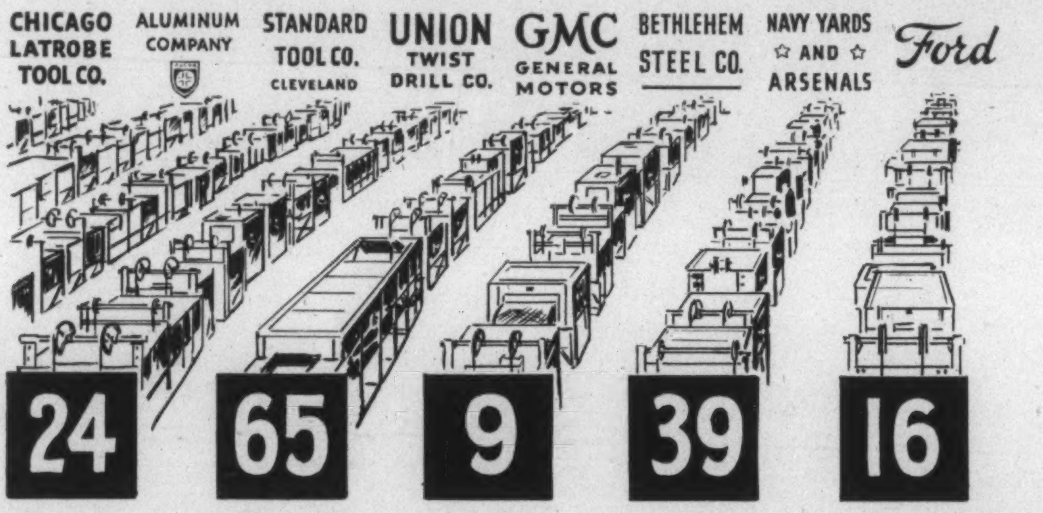
Heat Treatment of "K" Monel and "Z" Nickel

"Heat Treatment of 'K' Monel and 'Z' Nickel." Int. Nickel Co., Inc. *Heat Treating & Forging,* Vol. 25, Dec. 1939, pp. 593-597; Vol. 26, Jan. 1940, pp. 16-20, 25. Detailed, practical description.

"K" Monel contains approximately 66% Ni, 29% Cu and 2.75% Al. Its tensile strength ranges from 90,000 lbs./in.^{2} for soft cold-rolled strip, annealed cold-drawn wire, and annealed, hot-rolled and forged rods and bars to 170,000 lbs./in.^{2} for heated-treated cold-drawn bars and 200,000 lbs./in.^{2} for heat-treated full-hard strip and heat-treated spring-temper wire. Hardness ranges from 140 Brinell or 75 Rockwell B for the soft bars and strip to 320 Brinell or 33 Rockwell C for heat-treated cold-drawn bars and 40 Rockwell C for heat-treated full-hard strip.

"Z" nickel contains approximately 98% nickel. Its tensile strength ranges from 90,000 lbs./in.^{2} for soft cold-rolled strip, annealed cold-drawn wire and annealed, hot-rolled, forged and cold-drawn rods and bars to 190,000 lbs./in.^{2} for heat-treated cold-drawn bars, 230,000 lbs./in.^{2} for heat-treated full-hard strip, and 240,000 lbs./in.^{2} for heat-treated spring-temper wire. Hardness ranges from 150 Brinell or 81 Rockwell B for soft bars and 70 Rockwell B for soft strip to 380 Brinell or 40 Rockwell C for heat-treated cold-drawn bars and 46 Rockwell C for heat-treated full-hard strip.

Electric furnaces give the best results in heat treating these alloys. Properly controlled and operated radiant-tube gas furnaces give practically as good results, and are preferable to direct-fired gas furnaces. Small, properly constructed and operated home-made furnaces are satisfactory. The most fool-proof treatment requires the use of a sealed box as a container for the work. Oil firing should be used only for box heating, and then is likely to produce non-uniform hardening. Gas for gas-fired units should be burned in a precombustion cham-



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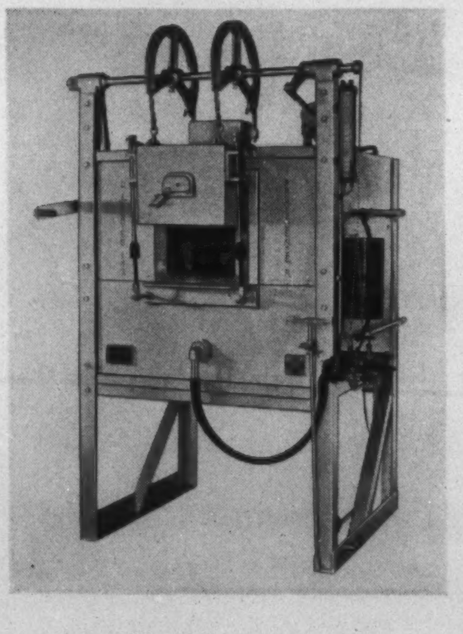

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ber and hot gases circulated freely around the box.

Heating up should be regulated so that the furnace itself will never get above the recommended heat treating temperature. Oxidizing atmospheres should never be used. If bright hardening is contemplated, this should be stated when ordering the material. Suitable atmospheres include hydrogen, cracked ammonia, nitrogen, cracked and sulphur-free natural or city gas, cracked hydrocarbons, or a generated atmosphere containing a combination of carbon monoxide, carbon dioxide, hydrogen, nitrogen and hydrocarbons. Propane and butane should be avoided unless soot can be prevented or removed.

For perfectly bright hardening, either pure, dry hydrogen or cracked and dried pure ammonia may be used. Any oxygen is removed by passing the gas through a small container of copper chips, externally heated to 1250° F. The gas is then run through a cooling coil and then through a drier containing activated alumina, silica gel, calcium chloride or other drying agent, with the drier located as closely as possible to the furnace. Iron and steel pipes, and containers for work must be free from rust and loose scale. Before heat is applied to the charge, the box or furnace must be purged to remove air and undesirable gases and to prevent explosions. For semi-bright hardening, other dry atmospheres may be used, but furnace or box should likewise be properly sealed and purged of air.

Sulphur may be removed by passing the gas through ferric oxide (Fe_2O_3). Undesirable amounts of carbon dioxide should be reduced to carbon monoxide by heating in the presence of charcoal, or removed by passing the gas through calcium hydroxide or sodium hydroxide solutions. Material for bright hardening should be degreased thoroughly, preferably by readily vaporized solvents. For clean heat-treated parts, either non-ferrous or highly alloyed ferrous containers are advisable. Direct-heated parts should never be placed on furnace floors.

Soft "K" Monel is hardened by holding for 16 hrs. at 1080°-1100° F., furnace cooling at not more than 15° F. per hr. to 900° F., and cooling to room temperature in furnace or air or by quenching. It can be hardened also by holding 1 hr. at 1200°-1250° F., cooling at not more than 15° F. per hr. to 900° F., and cooling further as above. Moderately cold-worked "K" Monel is hardened best by holding for 8-16 hrs. at 1080°-1100° F., and cooling at not more than 15° F. per hr. to 900° F. Sixteen-hour hold will give higher hardnesses, particularly if the material has been only slightly cold-worked.

Fully cold-worked "K" Monel is hardened by holding for 6-10 hrs. at 980°-1000° F., and cooling to 900° F. at not more than 15° F. per hr. In some cases, slightly higher hardnesses may be obtained with the longer holding time, particularly with material near the lower end of hardness range. In cases where lower hardness than maximum obtainable is satisfactory, the cooling rate may be increased.

"Z" nickel is hardened by a 2-operation treatment, but in most cases only the second is required, as the first—a high-temperature "solution" treatment—is usually carried out at the mill prior to the final stages of rolling or drawing. If the material has been heated to above 900° F. during fabrication, it will be necessary to repeat the "solution" treatment before it will respond to hardening. It is important that the hardening temperature indicated should not be exceeded.

Soft "Z" nickel is hardened by holding for 16 hrs. at 930° F., followed by furnace cooling or quenching. Moderately cold-worked "Z" nickel is hardened by holding at 900°-920° F. for 8-16 hrs., followed by furnace cooling or quenching; the longer hold results in additional hardness for initially softer materials. Fully cold-worked "Z" nickel is hardened by holding at 890°-910° F. for 6-8 hrs. Very hard-drawn wire can be heat-treated fully in 4-5 hrs.

"K" Monel cannot be bright annealed in any atmosphere except dry hydrogen. It should be quenched in a solution of 2% (by volume) of denatured alcohol in water to minimize oxidation. All sections thicker than ½ in. should be quenched to prevent partial age hardening. This need for quenching makes box annealing of such parts inadvisable. For full annealing, "K" Monel may be held at 1600° for 2-5 min. or at 1800° F. for ½-2 min. The age-hardening effect may be removed by heating to 1450° F. and quenching. Partial softening for machining may be carried out by heating to 1100°-1450° F. and quenching. This partial anneal, however, is not recommended as a general practice. Partially or fully annealed "K" Monel responds to hardening treatment.

"Z" nickel is subject to some depletion of essential elements when annealed. This is of importance only in the case of sections 1/32 in. or less. Where surface finish is important, the atmosphere should be dry hydrogen with addition of 1% hydrocarbons. Process annealing is carried out by holding at 1700° F. for 5-10 min. or at 1900° F. for ½-2 min. and quenching in a 2% (by volume) solution of alcohol in water. This will soften the metal but it must still be solution-annealed before it can be age-hardened. The solution treatment involves heating to above 1950° F.,

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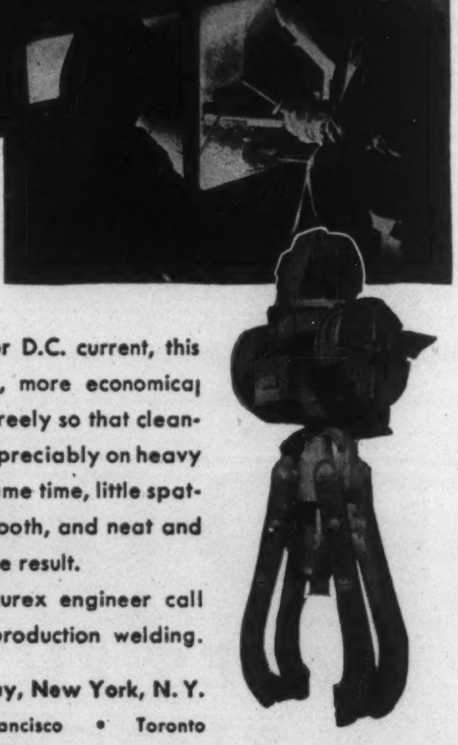

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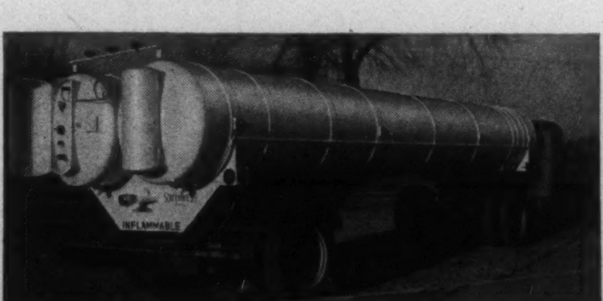

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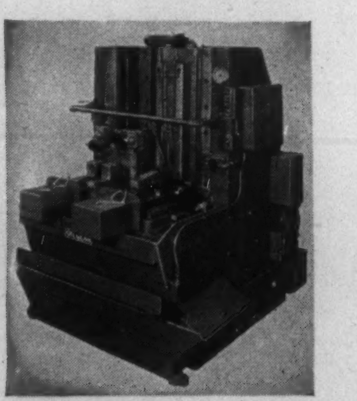

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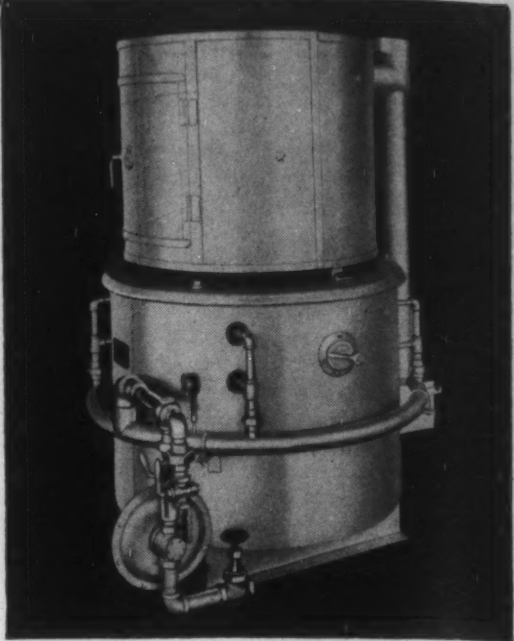

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removing from the furnace while the metal temperature is still rising, and quenching as rapidly as possible. It is best to operate the furnace at 2000°-2050° F.

Parts made from heat-treated and cold-formed "K" Monel or "Z" nickel and subject to fatigue or very high stresses should be stress-relieved by heating at 550°-650° F. for 1-2 hrs. If coil springs are to be given a cold "set" prior to being placed in service, the stress relief should be carried out before the setting operation. MS (2b)

Chromium Plating Dies and Molds

A Composite

Plastic molds are chromium-plated for resistance to abrasive wear and corrosion. In addition the chromium has a low coefficient of friction, which permits free extraction of the molded product from the mold. These and related points are discussed by A. W. Logozo of Gen. Electric Co. ("Chromium Plating Plastic Molds," *Monthly Rev. Am. Electroplaters' Soc.*, Vol. 27, Jan. 1940, pp. 11-21). The minimum thickness of chromium should be 0.001 in.

A uniform coating of chromium on the mold is important. If the mouth of a deep slot is more heavily plated than the recess, a back taper results, which prevents free removal of the plastic from the mold. Prior to plating, the mold must be highly polished with a flexible hand-polishing machine. The mold is given an alkaline cleaning and then an anodic treatment in a chromic acid solution.

After chromium plating, the mold is polished. To secure a more even current distribution on the mold, inside anodes are used. The "octopus" type of anode is widely employed. This consists of a number of lead wires, about 1/8 in. in diameter, attached to a lead-coated conducting bar. These wires can be placed so as to project into slots and recesses.

Since unplated molds are etched by the plastic, according to D. A. Cotton of Delco-Remy Div. ("Chromium Plating Dies and Gauges," *Proc. Am. Electroplaters' Soc.*, June 1939, pp. 61-67) recommends chromium plating particularly to prevent this. In addition many examples are given of savings effected by salvaging worn or undersized parts of various types with chromium plating. By chromium plating the rams of hydraulic presses, for example, the wear on the leather packing was greatly reduced. Chromium-plated parts that have been worn undersized are replated without stripping by giving them the anodic treatment that precedes each regular plating job. However, if bare steel is exposed, all the chromium must be stripped before replating. AB (2b)

Finishing Costume Jewelry

"Costume Jewelry Finishing." Louis Weisberg (Louis Weisberg, Inc.) *Products Finishing*, Vol. 4, Dec. 1939, pp. 9-25. Descriptive.

The operations involved in costume jewelry plating at the Cohn & Rosenberg plant start with a basis metal of either brass or white metal. The two lines are treated in separate plating rooms. A large part of the white metal is finished in rhodium, and the remainder in various shades of gold, while in the brass department gold finishes predominate.

All goods receiving bright finishes are provided with an undercoat of bright cobalt-nickel alloy. This finish covers solder marks, provides a uniform color, improves corrosion resistance and produces a better looking final finish. Clear lacquer is applied over the final finish. The cobalt-nickel alloy is not applied to pieces finished in the antique gold. Before plating, the work is given a soak in a solution of special soap and ammonia, followed by a water rinse, an electric cleaner, a water rinse, a cyanide dip, another water rinse and an acid dip. The cobalt-nickel alloy is plated on after a rinse following the acid dip. The cobalt-nickel solution requires constant agitation and filtration for perfect results. The final plating is applied after several water rinses.

The gold solutions require daily chemical checking plus temperature, time and current control to give the desired color and finish. Water rinsing and drying are used after the plating, following which lacquer is applied in a separate department. Antique gold is applied as a soft dark green gold plate of low karat which is relieved by brushing. Oxidized silver finishes are treated in much the same manner.

White metal parts require more hand cleaning because of the intricate shapes and the milder cleaning agents employed. Rhodium and gold plating of white metal follow about the same pattern as outlined for the brass articles. The jewelry set with stones presents special problems in keeping the foil backing for the stones as bright as possible during the plating operation, and in preventing sudden temperature changes, which might crack the stones. PCR (2b)

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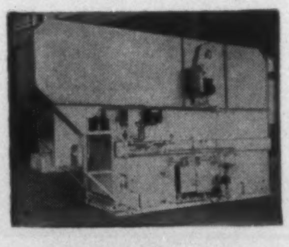

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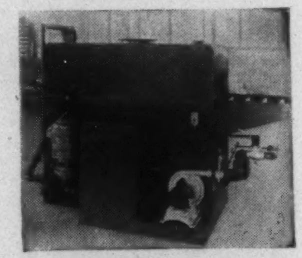

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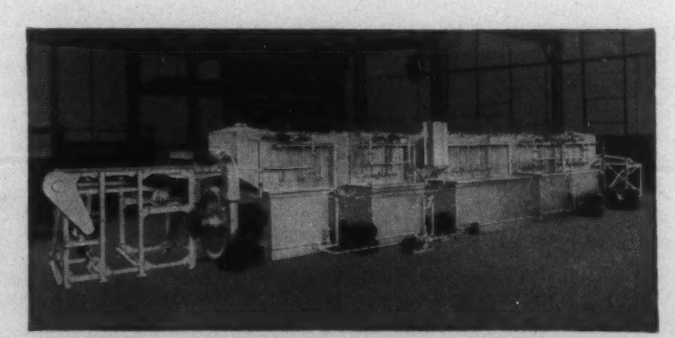

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Properties and Applications 3

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Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

Phosphoric Acid Corrosion

"Corrosion of Metals in the Manufacture of Phosphoric Acid by the Electric Furnace Process." Charles E. Hartford & Raymond L. Copson (Tenn. Valley Authority) *Ind. & Eng. Chem., Ind. Ed.*, Vol. 31, Sept. 1939, pp. 1123-1128. Review and research.

Serious corrosion problems are encountered in the manufacture of phosphoric acid by the electric furnace process. During the past several years the TVA phosphate fertilizer plant at Wilson Dam has studied these problems. This article describes the results of tests of metals exposed to corrosion by crude phosphoric acid and by crude phosphorus under actual plant conditions. Solutions of the difficulties are offered.

Exposure of small samples to crude concentrated acid revealed that the lowest corrosion rates were shown by cast nickel alloys containing large percentages of silicon, chromium or molybdenum; next lowest, cast silicon-iron alloys; then chromium-nickel-molybdenum low-carbon steels, chromium-nickel steels of the 18-8 type, chromium steels with 26-30% chromium, and copper alloys. Pipe lines of silicon-iron alloy gave over 2 yrs. of service in handling crude concentrated acid, and brass pipe gave better than 1 yr. service in concentrated and dilute acid.

Exposure to corrosive gases from electrostatic precipitators showed the least corrosion for 26-30% chromium steels, 18-8 nickel-chromium steels, and some of the high nickel-chromium and nickel-chromium-iron alloys. Ordinary carbon steel held up well enough to compete with the more expensive alloys. High rates of corrosion were shown by silicon-iron alloys and the copper alloys.

In tests of water-cooled tubes in a chamber in which gas from a phosphate smelting furnace was burned, copper tubes and 18-8 chromium-nickel steel tubes had the lowest rates of corrosion, but cast iron tubes were as economical. Results on over fifty alloys, all exposed under plant conditions, are tabulated. MEH (3)

Exhaust Valve Materials

"Exhaust Valve Materials for Internal Combustion Engines." S. D. Heron, O. E. Harder & M. R. Nestor. Paper presented at Detroit Regional Meeting, *Amer. Soc. Testing Materials*, Mar. 1940, 47 mimeographed pp., 20 references. Comprehensive review plus a mass of test data.

Exhaust valves operate at elevated temperatures, usually in the range of about 1200°-1400° F., but parts of the valve may in some cases reach 1600° F. Exhaust valve materials should possess at operating temperature a maximum of strength, resistance to stretching, and chemical inertness to oxygen and other constituents of the combustible charge prior to and after burning. Hardness of the material at operating temperature is an additional desirable property to avoid pounding, pitting, etc., of the portion of the valve that makes contact with the seat in the cylinder. A number of additional properties are now recognized as desirable or necessary attributes of an outstanding exhaust valve material.

These properties are intimately associated and unfortunately cannot satisfactorily be separated. Thus a material may have outstanding resistance to high temperature chemical attack (burning) by any of the constituents of the combustible charge which is burnt to produce power, but despite this chemical inertness, the material may fail much more rapidly than a much less inert material. In such cases the failure of the inert material may be due to lack of hot strength, creep resistance (resistance to stretching), and hot hardness.

This lack of necessary hot mechanical properties may result in the valve deforming so that it does not completely contact the seat in the cylinder and may also result in its riding the cam so that continual blow-by results. Whenever incomplete sealing of the valve occurs from lack of mechanical properties or other causes, the result is a sharp increase in valve temperature which may even result in melting a portion of the valve head. A less inert material with superior mechanical properties may remain in such mechanical condition as to operate at a far lower temperature, and as a result be effectively much more inert to the unburnt charge and to the combustion products.

A fundamental investigation leading to the development of steels designed primarily for exhaust valve service has been needed, in which the effects of adding one or more elements to an iron base could be studied with respect to properties necessary in an exhaust valve steel. The bottleneck of such an investigation, however, is the lack of laboratory test methods that will satisfactorily correlate with engine behavior.

At present the outstanding materials in respect to burning resistance in exhaust valves are 25 or more years old and were developed for entirely different uses. Much of the so-called valve steel research has resembled witch-doctoring. Magic materials have been added to generally known types of steels and tested in the laboratory by methods having no known correlation with engine behavior. As a result of these laboratory tests the alloys have been shown to have remarkable properties. Work of this sort has largely added to the already voluminous burden of misleading patent literature, and has become something of a nightmare to the engine development engineer. The authors would decline to predict completely the engine behavior of an exhaust valve material on any one or a combination of laboratory tests, except in the case of materials having relatively poor hot mechanical properties or poor scaling resistance, or both.

The results of accepting early and unwarranted generalizations is illustrated by the case of high-silicon steels. Because high silicon has proved of outstanding value in 9% chromium steels, there is now a general tendency to assume that high silicon is desirable in all chromium-containing materials, without reference to their chromium content or to the presence of other alloying agents. Dependence on sometimes irrelevant property-requirements has also hampered progress. Aitchison in 1919 stated that among the necessary requirements were high hot strength and high notched-bar impact values. These requirements have been repeatedly accepted, despite the wide and successful use of the 9% Cr, 3% Si steel (Silcrome No. 1), which is relatively poor in hot strength and in impact value at room temperature.

Hot corrosion is one of the most serious conditions exhaust valve materials must resist. Some low-alloy materials form surface films that are inert to most combustion products but are extremely reactive with the products of combustion of lead antiknock fluid. Hollow internally-cooled valves are in general use in aircraft engines and in limited use in other engine types. These valves are sealed and partially filled with a substance (sodium or sodium amalgam) that is liquid at operating temperatures. With such cooling, of course, the valve material must be chemically inert to the cooling material.

Cold corrosion usually is confined to the rusting and pitting of valve stems by condensed water vapor formed by gasoline combustion. Ductility, hot and cold impact resistance, scuffing resistance, wear-resistance, work-hardening properties and resistance to thermal shock (from overheating during hill climbing, followed by compression quenching) plus good fabricating properties are also desirable to varying and often undeterminable extents.

Hot hardness data are believed to be more significant than short-time high-temperature tension tests, which provide only a general guide in regard to stem stretching and head dishing. The importance of ductility is uncertain; many materials with

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low room temperature ductility give completely satisfactory service. High notched-bar impact value is generally desirable, but insistence on high impact resistance would have eliminated a number of materials with outstanding service records—for example, the chromium-silicon steels, which have been more widely used for exhaust valves than all other types put together.

Workability is important. The higher the hot hardness (a desirable service property) of the material, the less likely it is to be readily forgeable. Some of the very attractive valve materials like the Stellite alloys are commercially not forgeable at all. Steels of the 9% Cr, 3% Si type are the most readily forgeable valve materials now in service. Machinability of good exhaust valve materials is generally low. It is strange that additives to produce free-machining, such as those used in martensitic and austenitic stainless steels generally, have not been used in valve steels. Such additives should not significantly reduce either hot or cold corrosion resistance and might even improve scuffing properties.

Tests and data on hot-corrosion or scaling resistance have been the focal point of attention, for the importance of scaling resistance in a valve material is indisputable. Various methods, some laboratory, some engine-running, are described at some length. Experience with them has shown that no combination of laboratory tests of this and other properties can adequately predict the behavior of a given material in engine service. In developing a new exhaust valve steel (not yet announced) the authors made numerous composition changes to avoid manufacturing and engine operating difficulties, procured over 1,000 experimental valves, applied more than 10,000 hrs. of engine testing on the dynamometer and over a million miles of road testing—all of this with a type of steel that was outstanding in its first engine test.

Over thirty alloys can be classed as having achieved importance, although only temporarily in some cases, for exhaust valve applications. Those that are still widely used or that show promise of developing future applications are presented in the accompanying Table, with some indication of their serviceabilities.

Generally speaking, the martensitic or pearlitic steels are still reasonably adequate for the majority of passenger cars, but slight increase of duty may change this situation and make the use of austenitic steels imperative. The poorer wearing qualities of the latter must be recognized in the design and lubrication of valve stems and valve stem guides. In overhead valve engines austenitic steels require the application by welding of a harder material on the stem tip.

In aircraft engines the austenitic 14% Cr, 14 Ni, 1.75-3 W steel is most widely employed. The 80% Ni, 20 Cr alloy seems to be headed for growing application in valve service, as it is already very popular abroad. Nitriding of austenitic steel valve stems is largely used, resulting in a very thin case with a hardness of about 600 Vickers. Design plays a large part in the satisfactory functioning of aircraft valves and no combination of materials will give satisfactory service if the design is such that continual valve leakage occurs.

FPP (3)

Available Exhaust Valve Materials

Alloy Type	Alloy Composition	Type of Service	Application	Properties and Utility
Martensitic Steels	9 Cr, 3 Si (Silcrome No. 1)	Auto	Valves	Hardenable, with high critical temperature. Good all-round properties. Most widely used valve steel.
	19-23 Cr, 1-2 Ni, 2 Si	Auto	Valves	Hardenable. Better all-round properties than above, and rapidly replacing it.
	2.5-3 C, 1.5-2 Si, 0.7 Mn, 4-5 Mo, 3 Cr. Cast	Auto and Truck	Valve seat inserts	High as-cast hardness, fairly-well maintained at high temperatures. Excellent wear resistance. Widely used.
	As above, but forged, with lower carbon	Aircraft	Valve seat inserts	Limited application.
	25 Cr, 1 C, 1 Si	General	Valves	Promising, but still experimental. High burning-resistance.
Austenitic Steels (can be hardened only by cold work or nitriding)	18 Cr, 8 Ni, 3 Si	Auto	Valves	Low burning-resistance; better hot strength than martensitic steels.
	21 Cr, 12 Ni, 1 Si	Bus and Truck	Valves	Somewhat better than the alloy just above.
	14 Cr, 14 Ni, 0.5 Si, 0.5 C, 1.75-3 W	Aircraft	Valves	Most widely used steel for aircraft valves. Low burning-resistance, but successfully used with internal cooling and Stellite seat facing.
	25 Cr, 14 Ni, 2-3 Mo	Aircraft	Valves	Better scaling resistance than alloy just above, and better resistance to sodium corrosion. Not much better in very severe service performance.
	26 Ni, 14 Cr, 1.75 Si, 3.5 W	Aircraft	Valves	Widely used in Europe.
	16 Cr, 14 Ni, 1 C, 2-3 Si. Cast	Auto	Valves	Very high hot hardness. Used by one large U. S. manufacturer,
	14 Cr, 14 Ni, 3 Si, 1.75-3 W	Aircraft	Valve seat inserts for aluminum cylinder heads	Widely used by American manufacturers.
	12 Ni, 3.5 Cr, 5 Mn	Aircraft	Valve seat inserts for aluminum cylinder heads	Widely used in Europe. Has high thermal expansion needed for European threaded insert.
Age-Hardening Steel	24 Cr, 4.5-5 Ni, 3 Mo	Auto	Valves	Recent development. Age-hardens at 1400° F. to 42-45 Rockwell C (forms sigma phase). High burning-resistance. and better wear- and scuff-resistance, than austenitic steels. Sometimes brittle in head.
Non-Ferrous Alloys	65 Co, 27 Cr, 4 W, 2.7 Si, 1.25 C (Stellite)	Aircraft	Welded-facing on valve seats	Highest hot hardness, excellent burning, rust and wear resistance.
	80 Ni, 20 Cr	Aircraft	Welded-facing on valve seats. Also as valve body (experimental)	Growing in use in Europe. The alloy used (Brightray) can be acetylene-welded better than the standard American resistor wire.

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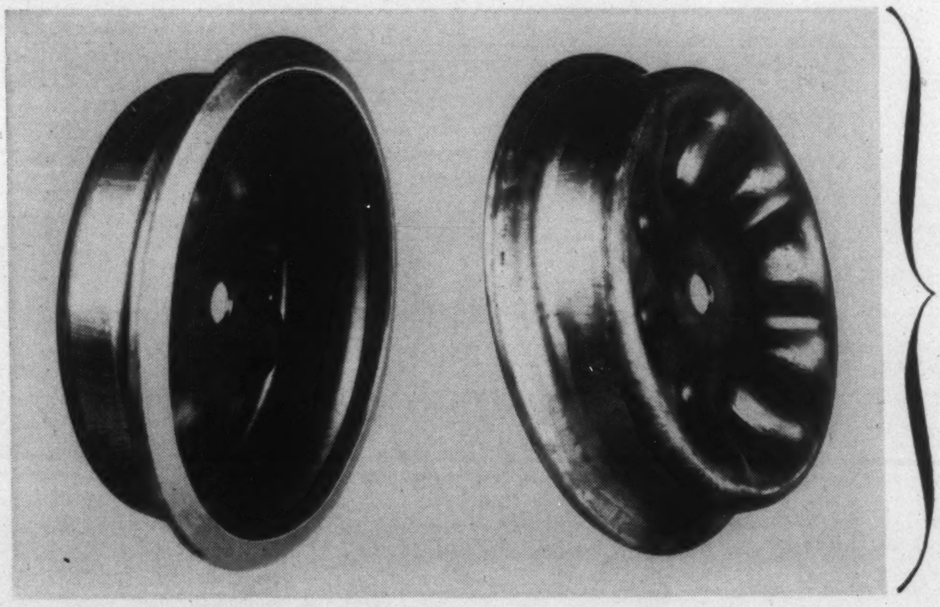

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particularly where there is something a bit tricky about the ideal design, the advantages of die casting as a fabrication method have been closely studied by metallurgical engineers. Such study has strongly tended to extend the use of die castings, although in many individual cases it has revealed how the part in question might be suitably designed and made in some other metal form, such as a stamping or a sand casting.

A practical discussion of the factors involved in choosing between stampings and die castings, with specific examples to aid designers in determining suitabilities for certain sets of conditions, is given by Herbert Chase ("Stamped or Die Cast—Which, When and Why!" *Iron Age*, Vol. 145, Jan. 18, 1940, pp. 36-39, 65). Stampings, including drawn parts, have a much wider field than die castings, but there are numerous cases in which either can be used. There are no unvarying rules to govern the choice, and a good knowledge of comparative physical properties and of production cost factors is required for each instance.

In general, the sheet metals from which stampings are made possess ductility, toughness and strength not commonly associated with cast metals. Zinc alloys, most widely used for die castings, have high ductility and impact strength, and a tensile strength about half that of mild steel. Aluminum die castings rank below the zinc alloy type in ductility and tensile strength, and much below in impact strength, but are important because of their light weight. Brass die castings have tensile strength approximating mild steel, good ductility and remarkably high impact strength. As to weight and stiffness, stampings weigh less than die castings, but this is often offset by greater stiffness in the die casting, because of variations in thickness and in shape, or from ribbing not feasible in the stamping.

Most stampings cost less than zinc alloy die castings. If, however, the requirements call for a non-ferrous or for a stainless steel stamping, cost may favor the die casting. On the other hand, if the special-metal stamping can be made thinner than the die casting, the lower weight of the stamping may offset higher material cost. When the specification for the part calls for variations in section thickness to provide bearings, mounting bosses, etc., the die casting presents marked advantages. One of the greatest advantages of stamping is the rapid production possible. However, die castings are completely formed in one operation, whereas stamping often requires several operations, frequently with intermediate annealings.

The die cost is a significant and frequently controlling factor affecting the choice between stamped and die cast parts. The die cost is usually lower for the casting than for the stamping, unless the latter requires little or no forming. Nevertheless, stamping is often cheaper than die casting, because the stamping is produced more rapidly, once the dies are available. The lower piece cost of stamping, however, may not offset its greater die cost unless quantities, say, over 100,000 pieces are made, in which case the differential in total cost often favors stamping.

Cost is not always the predominant factor in making the selection. Thus, in respect to dimensional accuracy and ability to maintain required tolerances as long as dies remain in service, die casting usually has an advantage over stamping. Holes may be cored at any angle in die casting, often requiring no further operation. Holes, of course, are punched in blanking and stamping, but if the part must be drawn, it is likely to require a separate die to punch the holes, a problem that is not present in die casting. In size, stampings can be produced larger than die castings, and it is possible to fabricate an assembly of stampings by welding, not feasible in most die castings. But for smaller parts, mechanical or decorative, die castings offer certain advantages in shape and sectional thicknesses possible in parts that are often cast in one piece.

In finishing and in the types of finish feasible, advantages can be cited for both types. Stampings are extremely smooth and can be formed from pre-finished stock; also, many finishes can be fired on stampings at temperatures above the melting points of most die castings. On the other hand, drawn parts often show ripples that are hard to remove. Today's die castings are so smooth that only a light buffing is required prior to plating, and many organic finishes are highly suitable for die castings. After long weathering, plated die castings often show less deterioration than steel stampings plated with equal care—one reason why die cast radiator grills are used in preference to the stamped type on many American automobiles.

Other reasons why the automotive industry is today the largest user of die castings are cited by R. L. Wilcox of N. J. Zinc Sales Co. ("Modern Die Castings for Modern Cars," *Metal Progress*, Feb. 1940, pp. 151-155). Their contribution to automobile styling, because of their amenability to production in a wide range of shapes and with niceties in detail not duplicable in other metal-forms, has been outstanding. For the mass production required in the automobile industry, too, die castings have been found ideal; scrap losses are negligible, machining is at a minimum, duplication is excellent, surface finishes usually at least as attractive as those possible on stampings, and mechanical properties satisfactory.

Probably 90% of die casting tonnage going into passenger cars is in zinc alloys, which are lowest in cost per lb, and in cost per casting. They are easiest to cast, particularly in thinnest sections. The earliest automotive die castings were for mechanical parts. Although such applications have increased, they now account for a smaller proportion of automotive die castings than do exposed parts, which are aesthetic as well as structural.

A typical example of the latter is the modern headlamp bezel, which, recessed into the fender as it is, offers design, fabricating and assembly problems that are most simply solvable by die casting. Radiator grilles, larger than the bezels, are more complex and expensive, and on most of today's cars are die castings—except in a few lowest-price cars where extremely large production warrants the heavy tooling cost that alone makes it possible to produce a stamped grille approximating the beauty of the die casting. Even in this bracket, however, we find Ford, Studebaker-Champion, Hudson and Willys all with die cast grilles. Other exterior applications of die castings include hood and body trim, hood louvres, "prow" moldings, name plates, license-lamps, running board fittings, and others.

Body interiors, too, employ many die castings, chiefly for reasons of smart styling and production economy. Radio grilles, instrument frames (the panel itself is a stamping), glove doors, body-door handles, steering-column parts, heaters and horn-rings are among the more common automotive hardware that have been die cast.

In the field of light and medium-to-small size machine elements, die castings most frequently compete, not with stampings, but with sand castings. A broad general comparison, plus detailed cost and design breakdown for a few specific instances, is again given by HERBERT CHASE ("Die Cast or Sand Cast," *Product Eng.*, Vol. 11, Feb. 1940, pp. 53-56). Zinc base die castings and ordinary gray iron sand castings are the materials compared, although other metals for either die castings or sand castings are, of course, available.

Among the outstanding advantages of gray iron sand castings are: Low cost of material, moderate cost for patterns and tooling, ease of casting at a fairly good production rate, good machining properties, strength adequate for a wide variety of uses, and hardness and freedom from cold flow. Included in the advantages of die castings are: Rapid production within dimensions so close that little machining is needed, thin sections and lighter weight, accurate coring at only slight or no extra cost, smooth surfaces without sand inclusions, lower finishing costs and superior strength, especially in impact.

Because of die costs, die castings are seldom economical when quantities required run below 1,000 to 5,000 unless the corresponding sand casting necessitates much core work, too much machining or too high costs for finishing. There are, of course, many large sand castings not capable of duplication in die casting, but there are also many small and some large die castings quite impossible to duplicate in sand cast form on an economical basis.

The specific gravities of zinc alloy and gray iron are nearly the same: 6.7 average for zinc alloy and 7.28 average for cast iron. The slight advantage in total weight of the zinc alloy on this score is increased in many castings, however, by reason of the thinner sections in which it can be cast and still have a wide advantage over cast iron in impact strength. Clock cases, for example, are produced with sections averaging about 0.030 in., and housings as large as 11 x 7 x 7 in. are made in sections averaging about 0.040 to 0.045 in. using zinc alloy. As against this, 3/32 to ⅛ in. is considered low for large iron castings

Coring involves several considerations which are different in die casting than in sand casting. In sand casting, cores as small as ¼ in. diam. are considered small and drilling usually preferable. Cores down to 1/32 in. diam. are used in die castings and almost any size hole, in which the depth does not exceed two to three times its diameter, can be and usually is cored, especially if in a favorable position. In general, however, the core cannot involve an undercut and, if it comes at an angle to the direction of die motion, some increase in die cost is involved.

External shapes can often be the same in die cast as in sand cast parts, but in each type some shapes can be made which are not feasible in the other type. Since a die is not flexible, the die casting must clear it when ejected, whereas the sand mold is destroyed after each casting. Patterns must clear the sand mold, of course, but they can be split or made with loose parts, or the mold can be parted in such a way as to yield castings not feasible in die casting. Many dies have slides carrying parts which form undercuts and the die can, in effect, be split in various ways when any extra costs entailed are justified. Great-

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er faithfulness in detail and greater sharpness of lines and edges are feasible in die casting.

Surface smoothness invariably favors the die casting or can be made to do so by care in finishing die surfaces. Dimensional accuracy, being much greater in the die casting, is among its important advantages. The much closer limits laid in die casting tend to reduce machining costs to an important degree. Sometimes no machining, except to remove flash, is required. When machining is needed in the die casting, less allowance for metal removal is made than in the sand casting.

Actual case histories are presented, based on parts that are or have been in production in die cast and/or sand cast form. Data in the examples given support the foregoing conclusions. The examples are instructive in themselves, as they constitute concrete evidence on costs and design advantages in a wide variety of applications. X (3)

3a. Ferrous

Damping Capacity of Cast Iron for Crankshafts

The Damping Capacity of Cast Iron with Special Reference to Cast Crankshafts ("Ueber die Dämpfung bei Gusseisen mit besonderer Berücksichtigung gegossener Kurbelwellen") J. Geiger. *Automobiltech. Z.*, Vol. 42, Dec. 1939, pp. 634-644; *Giesserei*, Vol. 27, Jan. 1940, pp. 30-32. Review and original research.

The advantages in using cast iron rather than forged steel crankshafts include not only the obviously lower material and manufacturing cost, but the reduced notch sensitivity (with only slight sacrifice in fatigue strength) and the much higher capacity for damping resonance oscillations.

Three methods for measuring the damping of a material under repeated torsional stress are reviewed: (1) Statical loading, releasing, reloading in the opposite direction, and releasing. The stress-torque curve forms a hysteresis and represents the energy consumed by internal friction. This method does not correspond to actual conditions which are characterized by rapidly alternating stresses. (2) The start-up method, which consists in measuring the increase of temperature from the specimen at rest to the specimen subjected to torsional fatigue stress. The difficulty here is the lack of a reliable method to measure the temperature inside the material without injuring the specimen. (3) The dynamic stress-and-release method, in which the specimen is loaded in torsion and then suddenly released so that it oscillates around its neutral position until the oscillation ceases. The objection to this method is that only a single loading is used instead of repeated stress. This is important especially in view of the resonance that may occur in actual engine runs.

The author developed a new principle of damping testing under conditions of resonance. A testing aparatus was developed which permitted making tests by procedure (3) above and by the resonance test, immediately following each other. The stress condition corresponds closely to that in engines at critical speed. The specimen is clamped tight on one end, and the other end is held in a ball bearing which allows torsional movement only. On this same side the specimen carries the oscillator mass which is activated by a motor driven eccentric.

From previously published data it may be concluded that the damping capacity is for all practical purposes independent of the frequency. In a comparison between the two test methods, it was found that the single stress-release method (No. 3, above) yielded values sometimes over 100% higher than those in torsion resonance. Since the latter method closely approaches actual conditions, it must be considered more reliable.

Using stresses as they may occur in shafts at critical speed, the following was found: The damping capacity is at first rather high (material not previously stressed), then decreases rapidly and approaches a constant value after about 200,000 stress cycles. It is to be noted that the stress was lower than the fatigue limit. Also, the possibility of changes in the damping capacity if the specimen has been allowed to rest for an extended period after stressing was investigated. Using various types of cast iron, no appreciable difference could be noticed when restressing the specimens after several weeks under the same conditions. In some instances the deviation was as high as 10%. This is attributed to other influences, such as chucking, etc.

It is already known that, for steel in general, the damping capacity is very low for low stresses; it rises rapidly with stresses, depending upon the type of steel used with the 3rd to 10th power of the stress. For ordinary cast iron, however, the damping capacity is only slightly variable with the stress as determined by the single-stress-and-release method. For higher grade cast iron the variability with stress becomes more pronounced; moreover, the values for low stresses are lower than those for low-grade cast iron. Curves taken for two different total numbers of cycles with the same material lie close together, especially above 200,000 cycles.

The curves plotted according to the author's resonance method are considerably lower. The differences between the different types of cast iron (higher damping capacity at low stresses for "ordinary" iron as compared to "high test") are present but are less pronounced. In the range which is important for crankshafts. the damping capacity for cast iron is roughly 80-120% higher than for the steels investigated (0.30-0.35% C, 0.67-0.8% Mn). The author warns against concluding from these results that cast iron crankshafts are so much safer than steel shafts. The whole assembly in the engine and the drive must be considered as part of the system and as entering into the set-up responsible for effective damping.

However, certain design changes may render it possible to utilize the higher damping capacity of cast iron to best advantage. Relatively high strength and high damping capacity are combined in the following analyses of cast iron: (a) 3.07% C; 1.10% Si; 0.89% Mn; 0.16% P; 0.10% S, and (b) 3.02% C; 1.07% Si; 0.79% Mn; 0.23% P; 0.12% S. RPS+Ha (3a)

Alloy Steels at Low Temperatures

Tensile Properties of Alloy Steels at Low Temperature ("Festigkeitseigenschaften legierter Stähle bei tiefen Temperaturen") A. Krisch & G. Haupt. *Archiv Eisenhüttenw.*, Vol. 13, Jan. 1940, pp. 299-308. Research.

Tensile, impact, and hardness tests were made of an extended series of 62 heat-treated alloy steels at temperatures down to —295° F.

In the impact tests the familiar sharp drop in impact resistance was obtained with most of the steels on lowering the temperatures below —60° F. The tensile strength and hardness increased as the temperatures were lowered. The elongation was little affected but the reduction of area was reduced to about half in most of the steels.

For the behavior of individual steels in the series tested, the original tables and graphs should be consulted. The impact resistance of lead and copper, also studied, increased at low temperatures. SE (3a)

Phosphorus in Low-Alloy Steels

"Phosphorus in Steel." C. H. Lorig & D. E. Krause (Battelle Mem. Inst.) *Iron Age*, Vol. 144, Oct. 19, 1939, pp. 33-37, 88; Oct. 26, 1939, pp. 28-31. Review plus original research.

In the experiments reported here, standard metallurgical practice was followed as much as possible. Melts were made in a high-frequency induction furnace and the steels were of the killed type, with addition of 2 lbs. of aluminum/ton. Ingots were rolled in 22-gage sheets or 7/8 in. bars. The steels were tested in both normalized and annealed conditions. Iron-phosphorus alloys were made with an ingot iron base so that the total amount of elements other than iron and phosphorus was very low.

Phosphorus increases the resistance of iron to atmospheric corrosion, according to tests run for 2 and 3 yr. periods; also, there was a constant rise in tensile and yield strength with increasing phosphorus. Iron-phosphorus-carbon alloys behaved similarly to iron-phosphorus in corrosion resistance. It appears, from the standpoint of notch sensitivity, that higher phosphorus can be used in steel with low-carbon content.

The tensile properties of low-carbon steels containing 1.3% Mn and 1.10% Si were enhanced by the addition of 0.18% P. In the annealed condition the strength was somewhat lowered because of the phosphorus. Manganese did not alleviate notch brittleness in annealed steels high in phosphorus. In atmospheric corrosion tests the high phosphorus steels showed excellent resistance, but this was not enhanced by manganese. Studies of high-sulphur steels showed that phosphorus in amount equal to the sulphur offsets the harmful effect of the latter on corrosion resistance. Copper improved the resistance to rusting of the iron-phosphorus alloys.

0.17% phosphorus can be added to 0.5% and 10% chromium steels, and toughness after annealing will still be retained. Phosphorus shows-up to best advantage, from the corrosion-resistance standpoint, in high-chromium steels. The addition of 0.18% phosphorus to a 3.6% nickel steel showed an improvement in corrosion-resistance over a 3-yr. period. All steels with 0.24% molybdenum and 0.18% phosphorus revealed excellent corrosion-resistant properties. The combination of molybdenum and phosphorus seems very favorable in steels, the beneficial effect of molybdenum being greatest in low-phosphorus steels. Vanadium behaves similarly to molybdenum in its compatibility with phosphorus. Atmospheric corrosion tests showed the benefit of high-phosphorus in copper-silicon steels.

To a low-alloy steel base containing 0.15% C, 0.60% Mn, 1.05% Si, 0.97% Cr, 0.37% Cu, 0.04% S and 0.016% P, phosphorus was added to bring totals up to 0.12, 0.22 and 0.32% phosphorus. Ductility values were satisfactory even for the steel with the highest phosphorus, and resistance to atmospheric corrosion was excellent. In copper-nickel-molybdenum steels, 0.17% phosphorus exerted a profound strengthening effect, with but small lowering of ductility in normalized conditions, and improved the resistance to atmospheric corrosion over a 3-yr. period by 28%. The corrosion resistance of a high-carbon, low-phosphorus-nickel steel was about as good

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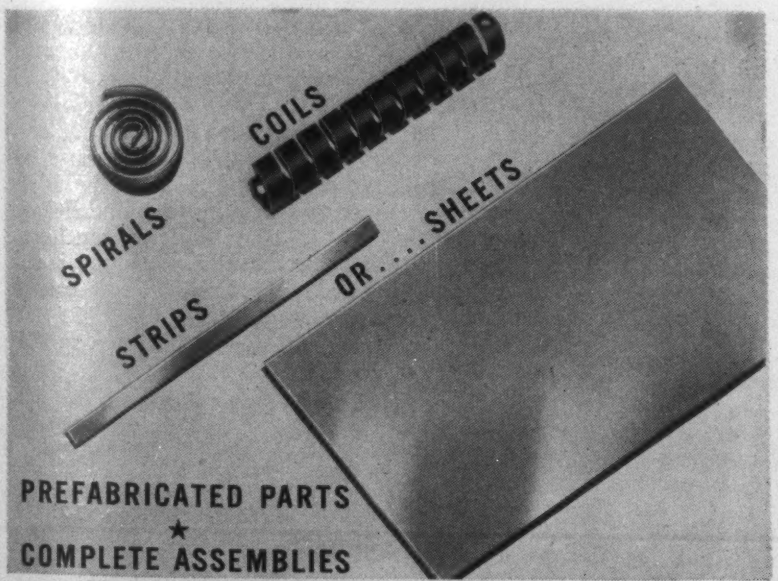

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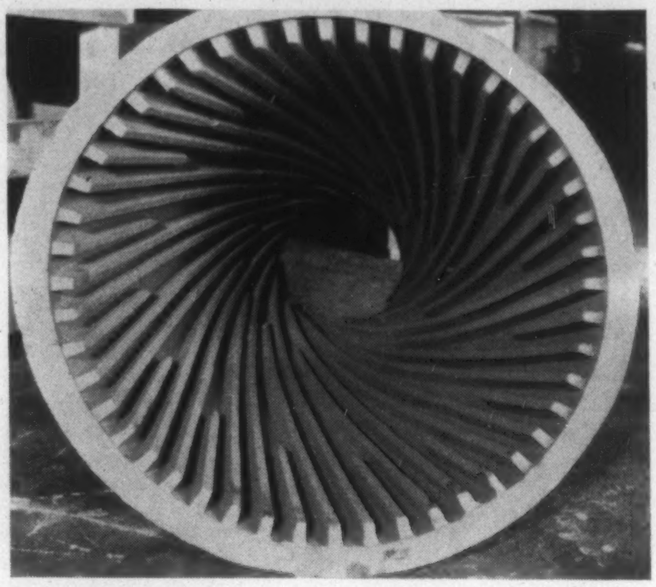

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as mild steel containing 0.17% phosphorus, and addition of phosphorus improved it still more.

The tests may be generally summarized as follows: The tensile and yield strength of plain and alloyed steels are increased by the addition of phosphorus. In both plain and alloyed low-carbon steel, the strength can be increased with little sacrifice of static ductility. Resistance to atmospheric corrosion is improved by the addition of phosphorus. VSP (3a)

Boiler Plate Embrittlement

Resistance to Caustic Embrittlement of Boiler Plate Steel in Relation to Its Aging Sensitivity, Heat Treatment and Aluminum Content ("Laugenbeständigkeit von Flussstahl in Abhängigkeit von Alterungsneigung, Wärmebehandlung und Aluminiumgehalt") F. Nehl & W. Werner. *Stahl u. Eisen*, Vol. 59, Oct. 19, 1939, pp. 1155-1157. Original research.

Six boiler steels containing 0.06 to 0.23% carbon, two of which were killed with aluminum to give 0.048 and 0.044% residual aluminum contents, were cold worked and aged to determine the loss in impact resistance on aging. Also, "Jones" caustic embrittlement tests were made by immersing specimens, bent by clamping, into hot caustic calcium nitrate and ammonium nitrate solutions. The specimens were tested in the as-rolled condition, after annealing, after quenching, and after normalizing and annealing.

There was no definite relationship between aging embrittlement by the impact test and caustic embrittlement. Low-carbon steels showed a greater tendency to intercrystalline corrosion by caustic solutions than did higher carbon steels, so that it appears best for resistance to caustic not to go under 0.15% carbon. The presence of aluminum has a beneficial effect, but resistance to caustic embrittlement was improved only when the steel contained over 0.04% aluminum.

In steels not killed with aluminum or in those with low-aluminum content, resistance to caustic embrittlement was obtained by annealing, or normalizing and annealing, at 730° to 780° C., or quenching followed by similar annealing. Air-cooling from the annealing temperature gave about the same resistance as furnace-cooling. Surface decarburization materially raised the sensitivity to caustic embrittlement. SE (3a)

3b. Non-Ferrous

Sand Castings or Permanent Mold Castings?

A Composite

On the face of it, one would expect the properties of permanent mold castings to be better than sand castings of the same material, and the casual observer may wonder why comparisons are necessary. Actually, chill-cast alloys depend on extremely careful design for superiority, and even then they may not be better in all significant respects. And in addition to design, cost factors have to be considered by both the foundryman and his customer. Two recent German articles have surveyed the pros and cons of sand and permanent mold castings —one on aluminum alloys and the other on copper-base materials.

An exhaustive investigation of tensile, bending and impact strengths of sand-cast and chill-cast aluminum alloys is reported by A. von Zeerleder ("Vergleich zwischen Aluminium—Sand- und Kokillenguss," *Giesserei*, Vol. 27, Jan. 12, 1940, pp. 12-14). The alloys tested contained (1) 5% Si, 0.7 Mn, 0.65 Mg and 0.15 Ti; (2) 7% Mg, 0.4 Mn and 0.1 Ti; (3) 4% Cu, 2 Si, 0.6 Mn, 0.2 Mg, and 0.15 Ti; (4) 4.5% Cu and 0.2 Ti; (5) 12.5% Si, 0.5 Mn and 0.3 Mg; and (6) 13% Zn and 3 Cu.

The permanent mold castings were consistently superior. Their tensile strengths were 20-80% higher than the same sand-cast alloys, thus permitting less weight for equivalent strength. The loss due to risers and gates averaged 30% lower for the chill-cast alloys.

Exact analysis was made of the cost of molds, labor, metal and scrap, and overhead to produce as-cast, half-hardened and full-hardened castings by both methods. Despite greater casting difficulties for permanent mold practice, the costs for castings so made were less. Other factors favoring chill-mold castings were their better appearance, closer dimensional tolerances and faster production rates possible.

Copper-base permanent mold castings were found superior to sand castings by Willi Claus ("Messungen an Kokillen-Formguss von Kupfer-Basis-Legierungen," *Z. Metallkunde*, Vol. 31, Nov. 1939, pp. 335-338). Tensile and hardness tests were performed on a number of chill cast brasses, a tin bronze, an aluminum bronze and a 70-30 cupro-nickel, and comparisons made with commercial (DIN) alloys in the sand cast state.

The faster solidification in the chill-castings prevents localized release of gases and inverse ingot segregation. Brasses with up to 60% copper may be used for chill castings without undue difficulties. The tin bronze tends towards heterogeneous cast structures and is recommended as bearing alloy if poured into permanent molds. Aluminum bronzes are considered as typical of chill-cast alloys whose handling offers no difficulties. On the other hand, the castability of 70/30 cupro-nickel was greatly hampered by lack of fluidity at the proper casting temperature. Considerable absorption of gases was encountered and the castings showed partial porosity.

Whereas chill-casting of light metals is a standard art, chill casting of copper alloys has come to the foreground only lately. Reactions occur between the mold material and liquid alloys at the necessarily high working temperatures. Aluminum additions may be as high as 1%, while in sand-cast brasses and bronzes aluminum contents exceeding 0.5% are "intolerable" because of the consequent porosity. X (3b)

Improved Type-Metals

"Bismuth and Cadmium in Type Metal Alloys." D. Swarup & M. Prasad. *Quart. J. Geo. Mining & Met. Soc. India*, Vol. 11, Mar. 1939, pp. 1-7. Original research.

Results of tests are reported on the effects of small amounts of bismuth and cadmium on the properties of type metal alloys containing varying amounts of lead, tin and antimony, with a view to improving their physical properties. The addition of cadmium improves the hardness and compressive strength of type metal. Bismuth improves fluidity and refines the grain size. Cadmium does not affect fluidity but does improve soundness in casting.

Alloys containing cadmium or bismuth show better wearing properties than those without. No attempt was made to estimate the combined effect of cadmium and bismuth on the properties of type metal alloys; it is possible that a suitable addition of cadmium and bismuth together may improve the fluidity as well as the hardness and soundness of type metal alloys. APS (3b)

4 Testing and Control

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

Hardness Testing

"D.P.H. Measurements with Rockwell Hardness Tester." J. H. Hruska (Electromotive Corp.) *Iron Age,* Vol. 145, Feb. 1, 1940, pp. 29-33.

The simplicity of the familiar Rockwell testing apparatus, together with its independence of the human factor in making the test, has made this machine the most widely used American-made hardness tester. Its numerous but rather small load-impression ranges, however, are definite shortcomings that make mandatory the use of elaborate conversion tables if some idea of the hardness of one material relative to others in general is to be obtained.

The pyramid principle of hardness testing, on the other hand, has appealed to many because of its theoretical relationship with an actual hardness scale of linear magnitude, with one scale covering the entire hardness range from the softest to the hardest industrial material. Therefore, some combination of the pyramid principle and the Rockwell machine was sought that would combine the definitely advantageous (and inexpensive) Rockwell principle of speedier measurement of impression depth and the more logical and metallurgically accurate application of the 136° diamond pyramid indentor.

The Rockwell testing machine used in the present work was a new apparatus of 12 in. capacity, equipped with a thoroughly calibrated 120° diamond cone. The comparative 136° diamond pyramid indentor was so designed as to permit the full use of the standard chuck of the Rockwell machine. Particular care was exercised to duplicate the principles set forth primarily by the originators of the pyramid hardness test. Measurements for the squareness of the resultant impressions were made with a 60, 100 and 150 kg. load on an alloy steel block of Rockwell C-63.5 hardness.

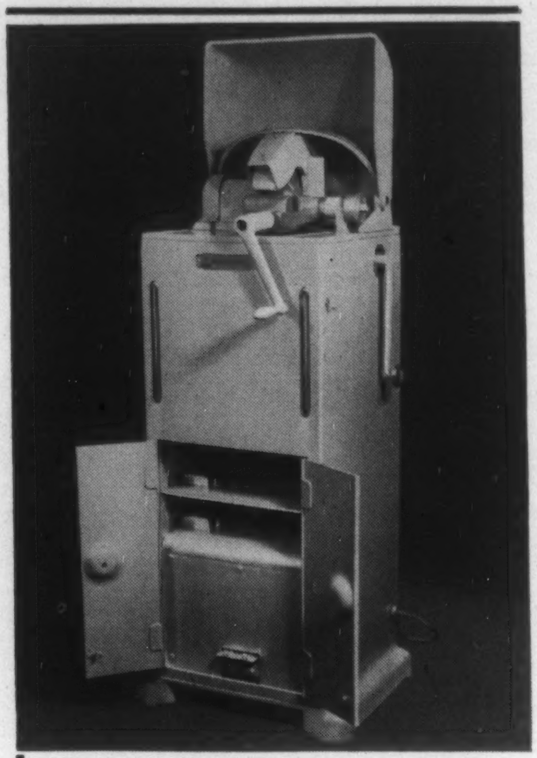
The reported readings were further checked by means of a standard metallurgical microscope of newest design at 100 magnifications, the ocular of which is an exact duplicate of the standard Vickers eyepiece. The Rockwell apparatus was, in all tests made, set so that the duration of actual loading conformed to minimum time required to conduct standard diamond pyramid tests.

Analysis of the factors entering into the functional performance of each testing machine makes it clear that the Rockwell scale is proportional only to measured depth of impression, whereas, the pyramid hardness is conventionally a function of the length of the diagonal in regard to a square impression. It is apparent that the depth of indentation of the 136° square-based pyramid is one-seventh of the diagonal of the impression. This decrease in sensitivity of the D.P.H. test on a Rockwell machine necessitates a more accurate reading of the indicator values on the dial of the apparatus, but it is naturally offset by the possibility to check also the diagonal by means of a suitable micrometer microscope.

A table is offered to enable the operator to determine D.P.H. numerals without much delay. From practical experience with this method it was found that the 60 kg. and perhaps the 100 kg. loads are probably the most suitable ones for general investigations, the 60 kg. load having a slight advantage for thinner materials tested. In the experiments, standard materials were tested by the "combination" machine and by standard Rockwell equipment with a new diamond.

In summarizing the tests made with soft and very hard materials and presenting these results in graphic form, the author finds reason to be somewhat amazed at the comparative accuracy of the tests. The mentioned test block, which represented materials of commercial grades, with their inherent and expected variations, indicated, nevertheless, that the general magnitude of the tests is uniform whether a 60, 100 or 150 kg. load be applied upon the pyramid indentor.

The correlation between the readings of Rockwell C hardness and the dial readings during the D.P.H. test is very clear. A comparison of the graphical relationship between these two hardness scales shows that they are amazingly close to the most recent conversion tables of Rockwell C and



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diamond pyramid hardness by Scott and Gray (see *Metals and Alloys*, Vol. 10, Dec. 1939, p. MA 724R/1), and are also within experimental error of the conversion tables published by the manufacturer of the Rockwell testing machine.

The somewhat detailed description of results obtained in this investigation seems to indicate that the accuracy of depth measurements of the Rockwell machine lends itself to determining D.P.H. hardness. It would, therefore, be perhaps a very remunerative experiment to design a depth gage which would read directly in D.P.H. numerals without reference to as many scales as the present Rockwell machine has to offer. In addition, it would eliminate the use of steel balls of admittedly variable hardness characteristics and variable sizes without the unavoidable inaccuracy of the test. Whether or not the same would be true of superficial Rockwell machines would naturally have to be proved by experiment.

VSP (4)

Tensile Test Motion Pictures

Micro-Tensile Machine for Making Micro-Movies During a Tensile Test ("Mikrozerreissmaschine zur mikrophotographischen und mikrokinematographischen Untersuchung der Werkstoffe") T. Pöschl. *Archiv Eisenhüttenw.*, Vol. 13, Oct. 1939, pp. 189-192.

A miniature tensile machine is described in which tiny tensile specimens in sheet form a few hundredths of an inch in gage length may be pulled to fracture. There is a camera attachment whereby either single micros, or micro-movies, may be taken during the course of the test.

An interesting series of such micros, at from 80 to 220 magnification, of polished and etched specimens tested in tension is shown. The micros illustrated the beginning of slip in certain crystals at the yield point, the progress of a crack in a brittle material, and differential flow between the softer and harder crystals of a 2-phase material. The manner of flow around punch marks and other types of notches is also illustrated.

SE (4)

Preparing Single Crystals

"The Growth, Orientation and Preparation of the Surface of Single Crystals of Copper." A. T. Gwathmey & A. F. Benton (Univ. Virginia) *J. Phys. Chem.*, Vol. 44, Jan. 1940, pp. 35-42. Original research.

In an effort to prepare single crystals of copper for use in the study of adsorbed gas by electron diffraction, considerable difficulty was encountered in obtaining satisfactory and reproducible surfaces.

The method described offers a simple way of preparing smooth surfaces on single crystals for use in the study of any of the surface phenomena of copper. The surface may be made parallel to any desired crystallographic plane. Single crystals of copper ⅝ in. diam. and 5 in. long were grown in a vacuum furnace in graphite crucibles by very slowly lowering (in 14 hrs.) the molten copper into a cooler section of the furnace.

The crystallographic planes are determined by the etching methods of Tammann & Sartorius. The single crystal is then clamped into a vise of a milling machine, and the surface is cut parallel to any crystallographic plane desired by means of a circular saw followed by grinding and polishing. A very bright and smooth finish may be produced by using the electrolytic polishing method. This latter method has the decided advantage of removing any strained or amorphous layers on the surface.

EF (4)

Short-Time Creep Tests

Creep Curves Obtained with a New Creep Testing Machine on Different Steels ("Versuche mit einem neuen Dauerstandprüfer über den Verlauf von Zeit-Dehnungs-Schaulinien verschiedener Stähle") H. Esser & S. Eckardt. *Archiv Eisenhüttenw.*, Vol. 13, Nov. 1939, pp. 209-222. Original research.

The design of a new creep testing apparatus is described, this consisting of the usual electric resistance furnace about the specimen and of dead-weight loading by a system of levers. The extensions are indicated by a Martens optical extensometer. The extensions are stated to be accurate to within ±0.2% and the temperatures to within 2.5° F. over the 1.6 in. gage length.

Two carbon steels, a molybdenum steel, and a chromium - molybdenum - vanadium steel were tested at 850° and 930° F. The creep curves were parabolic so that when the extensions *vs.* times were plotted on log-log paper they gave straight lines. It was concluded that such parabolic curves (straight lines on a log-log scale) could be extrapolated from a short test period of 10 hrs. to a period of 50 hrs. and, in fact, indefinitely.

Thus, it is stated that the short time creep test already in vogue in Germany, of

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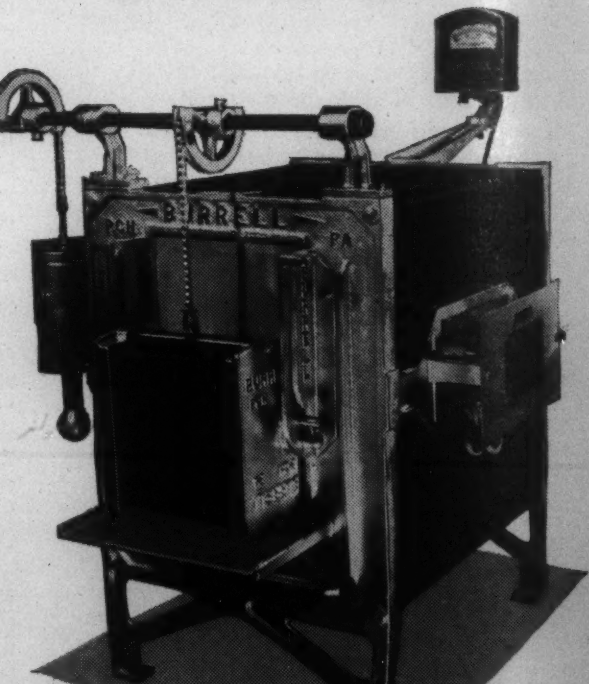
The heating chamber measures 4"x4"x13¼" deep. The floor is a removable, refractory plate with moulded sides to prevent spillage from reaching the insulation. Overall outside dimensions of the furnace are 26" wide x 30" high x 24" long.

The heating elements are designed to give long life but when it is necessary to replace them this operation can be done in five minutes without cooling the furnace.

Other standard models include muffle types—combustion tube types—and pit types. More information on request.



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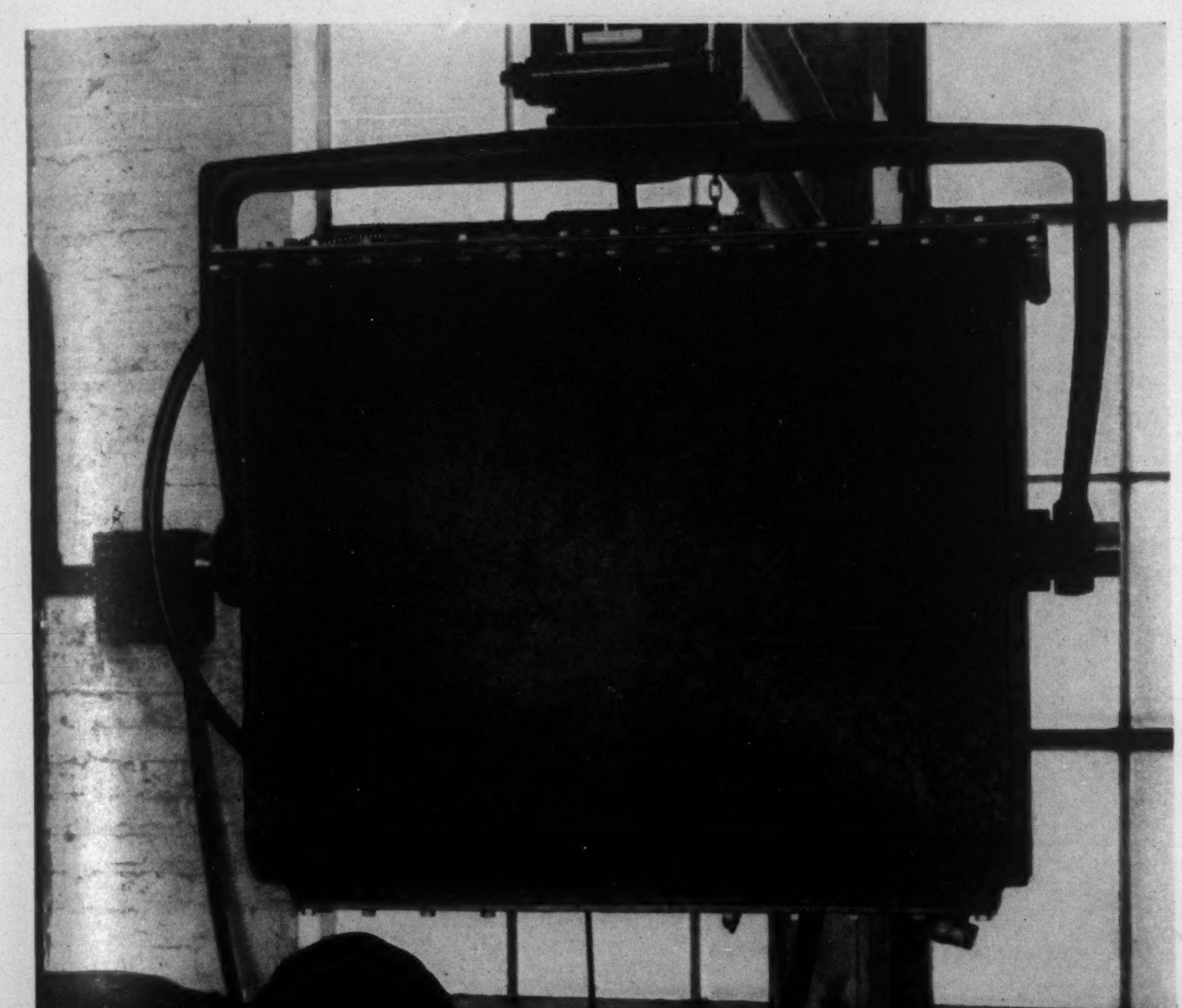

Courtesy Racine Steel Castings Co., a division of The Belle City Malleable Iron Co., Racine, Wisconsin

A large percentage of the Racine Steel Castings Co. tonnage consists of castings that will be subjected to extreme shock and stress loadings. Zealously guarded is their long-established reputation for high quality—guarded by a research laboratory that has complete chemical, physical, metallographic and x-ray equipment. The part that x-ray plays is important to both the foundry and its customers.

X-ray guides improvements in foundry procedures to establish controlled techniques that reduce rejects and failures. It determines fitness and quality; eliminates destructive tests because it tells the whole story of the continuity of internal metal. All of which aids materially in maintaining high quality standards that insure complete customer satisfaction.

The oil-immersed shockproof, climate-proof 200,000-volt unit in this progressive foundry's laboratory is designed and built to withstand the rigorous service expected of industrial equipment. And like all other G-E X-Ray Units it's mounted to provide full flexibility, ease of application, and simplicity of operation.

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45 hrs. duration, may be further shortened to 10 to 12 hrs., and that the creep limit of a steel may be accurately determined by loading it for 10 hrs. at a series of temperatures. An indication of the creep limit may even be obtained by loading 1 hr. at a series of temperatures.

In the discussion, it was brought out that such extrapolation was not applicable to steels which underwent structural changes at the testing temperatures. [This is another case of the Germans running long-time tests to determine whether extrapolation could have been made. All creep curves are not parabolic. Short-time tests are of value in comparing heats of similar materials, but in this country design will continue to be based on long-time tests.—H.C.C.] SE (4)

Fatigue Detection by X-ray

"Deformation and Fatigue of Metallic Materials as Detected by X-rays" (in German). Fritz Regler. *Forschungsarb. Metallkunde Rontgenmetallog.*, No. 26, 1939, 98 pp. **Research.**

Deformation of metals causes both peripheral and radial broadening of X-ray spots. A number of examples of peripheral broadening brought about by cold deformation and fatigue are shown. With moderate reductions the spots tend to merge to form lines, and with increased reduction the lines tend to break up to form the well-known fiber structure. Wrought iron members from an old bridge were examined. Some showed spots characteristic of undeformed material and others showed evidence of either deformation or fatigue damage.

The significance of radial broadening is discussed. Measurements of this broadening indicated that radial line width approaches a maximum characteristic of the material, which was termed the "fracture line width." This was 6.30 mm. for pure iron and as high as 7.80 for some alloy steels. On fractured fatigue specimens the line width rose slowly to a maximum at the point of fracture. On notched specimens the width increased abruptly at the notch. The maximum of line width on materials subjected to fatigue stressing but not fractured indicated the location at which fracture would ultimately occur. Measurements of line width in and near welds indicated positions of stress concentration.

Several practical applications of radial broadening of X-rays are given. One is in reference to axles from an electric locomotive in which one axle had failed by fatigue. Broadening of the lines at a change in section indicated a point of dangerous stress concentration and faulty design. Other axles of this design failed by fatigue and therefore indicated that the diagnosis was correct. Detailed directions for X-ray study of fatigue damage are given. JLG (4)

Radiography of Aluminum Castings

"Inspecting Aluminum Alloy Castings by X-rays." A. E. Cartwright. *Can. Metals & Met. Inds.*, Vol. 3, Jan. 1940, pp. 6-8. Descriptive.

X-ray inspection has been found of real value for the examination of welded structures of steel, etc. and for light alloy cast or wrought components. The low densities of aluminum and magnesium alloys necessitate only moderate sizes and powers in X-ray equipment, and hence have been significant factors in extending its use to such alloys.

At least two Canadian foundries have equipped themselves similarly to the larger foundries of Great Britain, permitting a complete inspection of aluminum alloy castings at the point of production under the supervision and check-up of the National Research Council. The X-ray equipment recommended for aluminum alloys includes the types within the 30-80 kv. range, which require a minimum of space and of safety precautions.

The Robert Mitchell Co. employs a high-voltage transformer unit containing the X-ray tube, which is connected by cables to the control unit. The whole weighs less than 100 lbs. and is operated from an ordinary 110-v. lighting circuit. Intensifying screens are recommended because of the lower powers and shorter exposures they permit. The maximum thickness of aluminum that may be examined with this equipment is 3-3.5 in.

Only castings passing surface inspection are sent to the X-ray laboratory. The defects most commonly sought by X-ray examination are blow holes, shrinkage cracks, porosity or pin-holing and inclusion of slag, sand or foreign metallic particles. Defects having a directional tendency and those favoring a notch effect are most serious. No means of measuring degree of porosity is as yet available and each casting afflicted with porosity must be subject to inspector's judgment.

There are some limitations of X-ray inspection that should not be forgotten. No magnification is at present possible for revealing defects too small to be recognized by normal vision. Also, if used to determine gas- or liquid-tightness of parts, X-ray testing may mislead one into rejection of actually pressure-tight castings, or acceptance of castings that are anything but pressure tight. Leakage cavities are significant because of their continuity from inside to outside, rather than because of size.

WHB (4)

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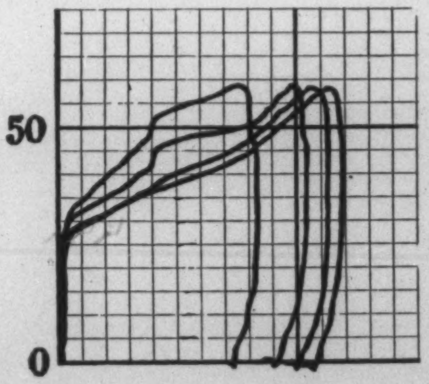

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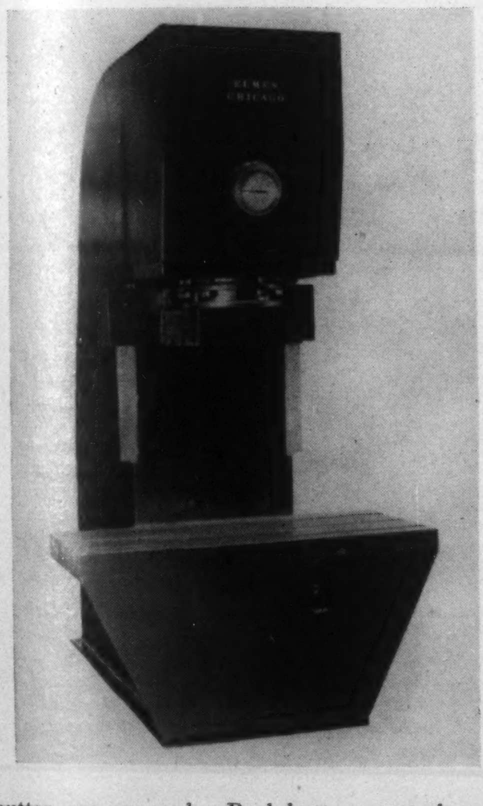
"The result of modernization and numerous minor improvements," is probably the best way to describe the Elmes General Purpose Open Side Hydraulic Press. It is of exceptionally sturdy steel construction and the frame is properly reinforced to give the maximum amount of rigidity. The bed is located at a convenient working height from the floor and is provided with slots for fastening jigs or fixtures. The moving platen is accurately guided on adjustable gibs located on the frame. T-slots are also provided in the moving platen. The control equipment is located within the housing. Only the operating levers and motor starter button are exposed. Push-button control may be provided if desired.



The operation of the press is by a single lever conveniently located on the right-hand side of the press. Pushing down the lever advances the platen at a high rate of speed and, when the work is reached, the platen automatically slows down. Releasing the lever will reverse the platen, which returns at a considerably higher rate of speed than it descended. By the simple movement of a rod, the stroke of the moving platen can be decreased to cut down the idle movement of the platen. In production work this is an especially desirable feature. Louvres are provided in the rear of the press for proper ventilation of the motor. Any adjustments necessary can readily be made by opening the hinged cover located in the rear. Valves needing adjustment for pressure variation are very easily reached. This press is available in practically any size or capacity. Engineering data are available from the Charles F. Elmes Engineering Works, Chicago.

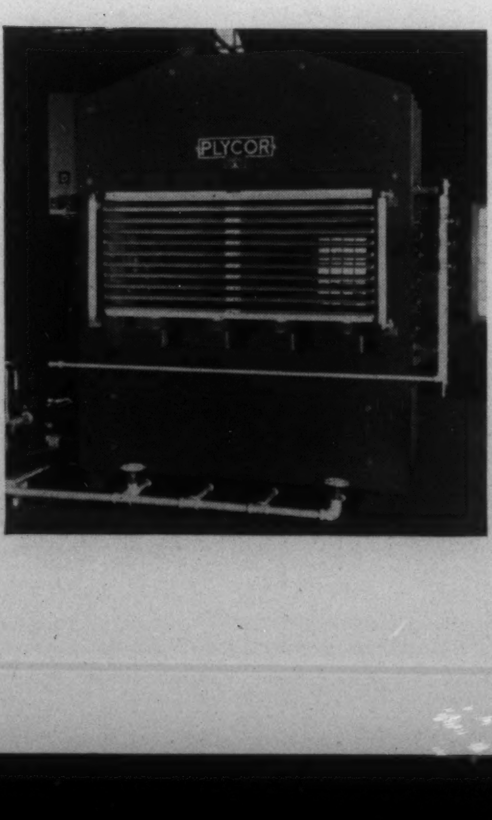
> Manufacturers are invited to send to the Editor items which are suitable for this Department. Illustrations are acceptable, preferably in the form of cuts not more than 2 in. wide.

Hot-Plate Presses

The Adamson Machine Co., Akron, Ohio, in conjunction with their associate, the Plycor Co., of Chicago, designed and are now producing hot-plate plywood presses used in the manufacture of plywood panels. These presses are known as "Plycor Hot-Plate Plywood Presses" and are built exclusively for the Plycor Co. Illustrated is a 106 by 55-in. ten-opening press which has just been completed at the Akron plant.

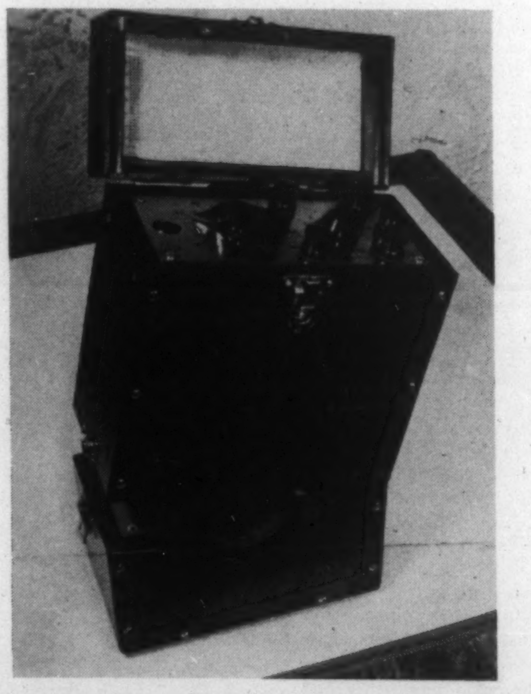
Production conditions require that the plywood panels being pressed maintain an overall accuracy of thickness to within five-one-thousandths of an inch. As a result, pressure tightness of the press rams and cylinders must be maintained steadily and is a vital factor in design and selection of materials. To meet this requirement, wear of the rams and cylinders in service must be reduced to the lowest possible minimum. For this reason Meehanite castings are used in both the rams and the cylinders, the rams being hardened by heat treatment to approximately 425 Brinell.

Experience has revealed that these rams provide a uniform surface hardness which gives even wearing and grinding qualities. The combination of the heat-treated ram and the bearing surface of the Meehanite cylinder results in practically negligible wear when used with the oil hydraulic system which is furnished as a unit with Plycor presses.



Glow Tube Meter

The New Weltronic "Glow Tube Meter" is described as a small, light, inexpensive instrument, which provides a convenient means of taking measurements of welding current and of voltages of such short duration as 1 cycle on a 60-cycle circuit. The instrument can be used also to measure continuous current flow and voltages. It helps to eliminate guess-work and allows accurate prediction and duplication of results. The instrument will measure current from 50 to 50,000 amps. and voltages from 0.5 to 550 volts on a 60-cycle circuit, where the current or voltage wave is approximately sinusoidal in character. Calibrated by an oscillograph for current and by a high vacuum tube volt-meter for voltages, it can be used with circuits or other than 60-cycle by using a corrective factor. Tabulation chart with complete instructions is supplied with each meter.



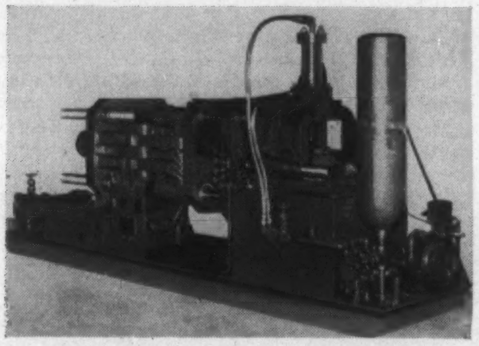
The principle of operation is extremely simple. The assembly comprises a special air core transformer for use in current measurements, a small potential transformer for use in voltage measurements, a special and accurately calibrated rheostat and a small neon glow lamp. In taking readings of current the hinged window is closed over an electrode arm or cable and with the selector switch set according to the instructions accompanying the meter, the large dial is turned clockwise until the glow lamp does not flash. Now the large dial is turned clockwise until a point is reached at which the glow lamp will just flash on both sides of its electrodes every time a weld is made. The tabulation chart supplied with the meter indicates the value of current for each dial setting. No expert knowledge is required. The instrument can be used by any electrician or welding maintenance man. Send for Bulletin WT-RS-1, for more complete information, to the Weltronic Corp., 2832 E. Grand Blvd., Detroit.

Die Casting Machines

The G & M Mfg. Co., Cleveland, has developed two new and greatly improved high-pressure hydraulic die-casting machines, one for zinc, tin and lead-base alloys, and the other for aluminum, brass and magnesium alloys.

Similar in engineering and construction, the machines are said to be designed to accommodate larger dies, to increase production and reduce waste, to give a tighter seal on dies and largely eliminate flash, and generally to facilitate the die-casting process.

Highly important to the performance of the machines is their unusual construction. Base, framework, die plates and toggle links are made of solid steel plates, flame-cut and welded. The result is claimed to be a type of die-casting machine heavier and stronger than any previously manufactured, better able to stand the terrific wear and tear of high-speed production schedules. Construction of the extra-heavy die plates is such that any possibility of breakage is eliminated. Maintenance costs are said to be cut to an absolute minimum. The toggle arrangement permits moving and locking of the die plates with a hydraulic pressure of less than 300 lbs. against the actuating mechanism.



One feature of the toggle linkage is that no strain is exerted on the link pins in stopping the forward motion of the moveable die plate, as would be the case if shoes or stops were used on the links themselves. Instead the machines are so equipped that the actuating movement of the linkage is stopped when the hydraulic piston which moves it comes in contact with the moveable die plate when the die is locked. Steel hardened bushings are used on all bearing surfaces in the toggle linkage, and the link pins themselves have an exceptionally large diameter.

Exhaustive tests are said to have proved the machine capable of turning out castings with greater strength, a higher degree of precision, closer tolerances and thinner wall sections. Smoother surfaces reduce polishing costs and make plating easier and more economical. In designing the machines, everything possible has been done to increase efficiency of operation and to reduce lost motion.

The base itself, 48 in. wide and 182 in. long, weighs approximately 4,000 lbs. It is flanged on all sides to prevent water from the die-cooling system from running onto the floor, and is reinforced with a 6-in. steel channel and cross members to add maximum rigidity and prevent weaving. A hydraulic valve arrangement for ejecting and core-pulling is standard equipment on both types of machines.

The zinc-tin-lead-alloy machine is designed in such manner that the gooseneck or the furnace pot can be replaced without disturbing the hydraulic piping. Weight of one machine, skidded and crated, is 18,000 lbs.

Steel in Powder Form

"Sinterloy" is a powder which may be pressed into any desired form by the standard methods of powder metallurgy, according to the Alloys Powder Co., with Charles Hardy, Inc., 415 Lexington Ave., New York, as exclusive distributors. This compound can be obtained in 3 compositions for the production of steel, after sintering, of carbon content of about 0.15, 0.4, 0.8 per cent. Sinterloy is claimed suitable for products such as gears, cams, pump rotors, washers, pins and rivets. It may be hardened by heat treatment, it is said. It is available packed in 25, 100 and 200-lb. net weight drums.

K-42-B—A New Alloy

Most significant of recent alloys to emanate from the Westinghouse Research Laboratories is K-42-B, said to be stronger than any known steel, containing only 7 per cent Fe—yet retaining its strength at temperatures higher than 2000 deg. F. A result of almost 7 yrs. of work by Westinghouse research metallurgist P. H. Brace, K-42-B is a first cousin of another Westinghouse alloy known as "Konal"—a practical substitute for platinum in oxide-coated radio tube filaments, costing about one three-hundredths as much as platinum.

The new K-42-B is stronger at 1100 degs. than ordinary low carbon steel is at room temperature. Stranger still, it has a low damping coefficient—or in other words, it retains its elasticity—at such elevated temperatures. As a vivid illustration of this property, Brace had two small bells made, one of steel, the other of K-42-B. Heated to 1100 deg. F., the steel bell responds to a hammer blow with only a thud, but the new metal rings with a clear, resonant tone.

Almost half of K-42-B is nickel; about a quarter is cobalt. But it has other components including chromium, titanium, and iron. Production of the metal on a commercial scale is known to be practical, but its first cost will be high, and its immediate uses are expected to be those of a special-purpose alloy for dies, valves, steam fittings, possibly turbine blades, or other applications requiring temperature-resistant metals.

The new alloy "creeps" a great deal less than other metals in its class. Sample rods of the metal were loaded in tension to produce a stress of 20,000 lbs. per sq. in., and heated in an electric creep-testing furnace for 6,000 hrs. at a constant temperature of 1,000 degs. F.. At the end of the test, K-42-B showed a yield of only one ten-thousandth of an inch for each inch of its length, and most of this had taken place during the first few hours. Under the same conditions a sample of high-strength nickel-chromium steel yielded 100 times as much. Cast carbon-molybdenum steel would have failed completely, long before the 6,000-hour mark was reached, it is claimed.

Spray Painting Outfit

Featuring an attractive, modern, streamline design, unusual performance and an appealing price, a new series of small spray painting outfits, known as the NCB, has just been announced by The DeVilbiss Co., Toledo, Ohio. Although the line consists of five different spray equipment assemblies, all outfits are built around a radically new and different ¼ h.p. electric motor-driven air-compressing unit. Three are cup gun outfits and two include a pressure feed paint tank of two-gallon capacity.

The air-compressing unit is said to be novel both in design and construction. It is composed of a ball bearing, piston type compressor, direct connected to a standard ¼ h.p. motor. These together with the air strainer, crank case and pulsation chamber form an integral unit enclosed in a streamlined housing. Exterior surface has been given an attractive crystalline finish in two colors.

More outstanding than its design is the performance claimed by the manufacturer. The unit is said to have the capacity of most ⅓ h.p. and many ½ h.p. outfits. Rated displacement is 4.3 cu. ft. of air per minute at 40 lbs. pressure. Actual air delivered at this pressure is 2.6 C.F.M. Maximum pressure is 50 lbs. Construction is sturdy and the outfit will perform consistently without breakdown or repair, it is claimed. The unit is compact, light weight and easily carried. Provided with four rubber feet, the outfit is free of vibration and will not crawl.

The company's advertising claims that the equipment will handle a wider range of small painting jobs and do the work faster because of the volume of air produced by the new air compressor. Better painting results are promised from the sustained high pressure without let-down. These new outfits are being stocked by all DeVilbiss distributors where they will be displayed and demonstrated.

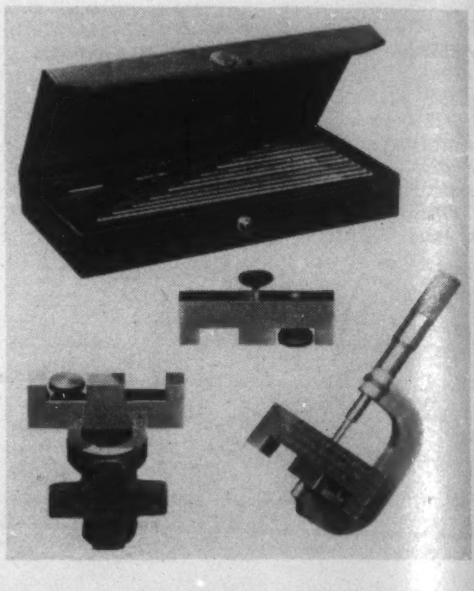
Height and Depth Gage

The Doall Height and Depth Gage is a new product recently announced by Continental Machines, Inc., of 1301 Washington Ave. South, Minneapolis, Minn. An immediate claimed advantage of the new Doall Gage is that it makes for easy reading with micrometer accuracy of the most hard to get at places. The Gage is furnished with rods which measure up to 6 in.

As a depth gage, or as an inside parallel surface gage, the measuring rods are locked into accurate position after the measurement is taken. The accurate depth obtained is then quickly read from a micrometer. No need to add or subtract to get a reading.

Besides its use as a measure for inside dimensions, the gage also is used for height measurements in which case the special height pin is inserted in the gage in place of the measuring rods. With the height attachment, the gage can be used for making accurate layout lines which are especially good for operations under magnification, since the Doall Gage does not tear the metal.

The use of the gage is such that a 3-point contact is maintained whether it is used as a height or depth gage, or for measuring inside parallel surfaces. This makes for extreme accuracy of measurement at all times. An interesting use of the gage is for checking the dimensions of stampings. It is also used in place of a production gage for checking small quantities of parts.



The handy and versatile Doall height and depth gage is available in the deluxe set, complete with the disc scriber, and measuring rods for up to 6 in. capacity, in a velvet lined case.

Electroplating Unit

With the turn of the new year, the W. Green Electric Co., Inc., 192 Broadway, New York, has placed upon the market a new and novel electroplating unit under the trade name of "Selectro-Plater," which bids fair to fill an important place in the field of electroplating. Engineered by Joseph B. Kushner, Ch. E., and the engineers of the International Telephone & Telegraph Co. for The W. Green Electric Co., Inc., this modern plating unit incorporates the new Selenium Stack and is a complete plating unit in itself.

The initial unit has been designed particularly for jewelers, dental laboratories, small plating plants, trade schools, hobbyists, experimental laboratories and small plating rush work in large commercial plants. It will deliver 7½ volts and 4 amps. on continuous load and will give well over 8 amps. on intermittent load or flash plating. It operates on a.c. only, at line voltages of 105, 110 and 125 volts. This new, small power plant is a completely functioning unit, sturdy, compact and light in weight. The dimensions are approximately 10 x 6 x 5 in., weight about 10 lbs.

To plate, plug it into the a.c. electric outlet, connect the cathode and anode leads to the binding posts and plate. A unique single knob to adjust the voltage from 0 to the maximum variable control on the panel enables the plater voltage as measured by the accurate panel voltmeter.

(Continued on page MA 244)

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Mack builds lighter and stronger . . . Reduced dead weight . . . faster schedules . . . safe, economical transportation. "A.W". Dyn-el high strength steel plays an important part in the construction of Mack Buses for 1940. Mack eliminates every unnecessary pound of weight with "A.W." Dyn-el. With all its lightness, Dyn-el is stronger than conventional steel, longer lasting and has greater resistance to shock, fatigue and corrosion. *Fewer pounds of steel to buy means fewer pounds of steel to move.*

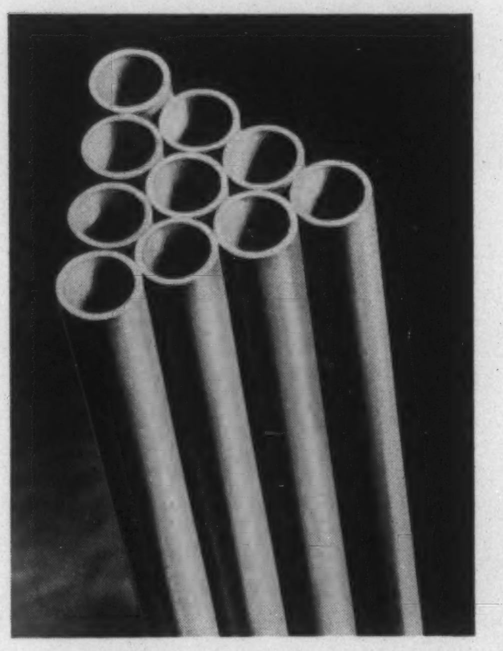
The 48-page book, "A.W." Presents Dyn-el, gives full details of savings in weight and cost possible with this new high-strength, flat-rolled steel. Write for a copy.

ALAN WOOD STEEL COMPANY

MAIN OFFICE AND MILLS, CONSHOHOCKEN, PENNA. : : SINCE 1826 : : DISTRICT OFFICES AND REPRESENTATIVES—Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, St. Paul, Pittsburgh, Roanoke, Sanford, N.C., St. Louis, Los Angeles, San Francisco, Seattle, Montreal—A. C. Leslie & Co. PRODUCTS INCLUDE—Steel Products in Carbon, Copper or Alloy Analyses : : Sheared Steel Plates : : Hot Rolled Sheets and Strip : : "A.W." Rolled Steel Floor Plates : : Billets, Blooms and Slabs : : "Swede" Pig Iron : : Reading Cut Nails.

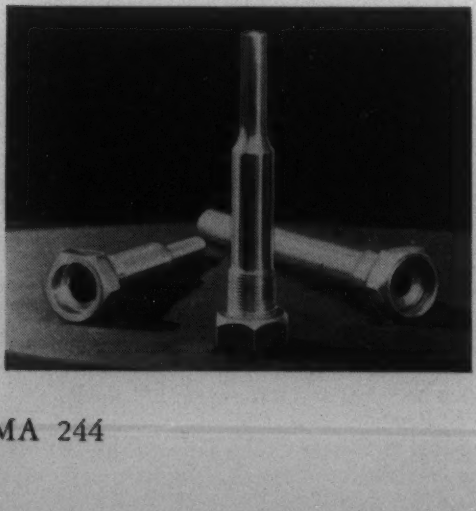
Illium Thermocouple Protection Tubes

Illium, the non-magnetic, corrosion resisting, complex nickel-chromium base alloy, with a more than 20-yr. record of satisfactory service to industries using or making industrial corrosives, recently announced new available forms including rolled strip, welded tube, rolled rod stock and a limited amount of drawn wire. Now there is a still newer development—the fabrication of high grade thermocouple protection tubes from illium tubing. Already one of the largest steel companies is using them in a variety of sizes ranging from 5 to 7 ft. in length. These tubes average 1 in. o.d. by 0.083 in. to 0.062 in. wall. The service is in a highly oxidizing electrolyte solution of 25 per cent sulphuric acid at 150 deg. F. with admixtures of other acids and salts.



Illium's outstanding resistance to many acids, soluble oxides and salts has proved it to be in many cases the most economical construction material available for use where unusual corrosion resistance, high strength, machinability and the ability to withstand abrasion are needed in one material. Illium is extensively used in sulphuric and in nitric acid services for equipment which comes into constant contact with acids in various concentrations, varying degrees of pressure, agitation or flow and under varying thermal ranges. There are many other applications where illium can be used to advantage. A partial list of the industries employing illium includes the drug, chemical, food, mining, explosives, paint, paper, rubber, oil, soap and textile industries.

With the introduction of illium strip and rolled stock, the field of its usefulness is, of course, greatly widened. Illium was formerly available in cast form only. Now, in addition to rough cast, rough machined or finished pattern castings, centrifugal cast tube and cast bar stock, illium is furnished in rolled strip in U. S. S. gages from 8 to 34; butt-welded tube made from strip stock; rolled rod for use in screw machines, as tie rods, shafting or pins. Forerunners of the new illium welded thermocouple tubes were the machined and polished illium cast thermometer protection tubes widely used today by instrument manufacturers to combat severe service conditions.



The Burgess-Parr Co., Freeport, Ill., offers the services of its technical staff in consultation, without obligation, to any organization having a production problem for which illium appears to be a likely solution. If present manufacturing methods use a material that is unsatisfactory and costly from the standpoint of too frequent replacement, contamination, limited available form or excessive vulnerability to erosion or abrasion, it might be well to consider illium for reduced operating costs.

Present day illium, its properties, characteristics and its range of serviceable applications, is presented in Bulletin No. 103-M, copy of which may be had upon request from the manufacturers, the Burgess-Parr Co., Freeport, Ill.

Master Copy Type of Plastic Material

The introduction of master copy type, made of durable plastic material, for three-dimensional pantographic engraving and die-cutting machines, is announced by H. P. Preis Engraving Machine Co., 157 Summit St., Newark, N. J.

This type is intended for producing steel letter stamps, type, and various classes of dies. It is furnished in heights of $\frac{5}{32}$, ¼ and ½ in., and in 8 variations of width, from very condensed to very extended. The face of the character is formed with a double bevel, the lower being 20 deg. from center line and the upper 35 deg. Because of the steepness of the lower bevel, the base of the character is relatively narrow, thus permitting very close spacing. The greater angle of the upper bevel provides a strong structure, preventing breakage and retarding wear. For ease of lining up, a stud projects from the back of the character.

The contours of the letters and figures, and the space distribution, have been very carefully worked out for pleasing appearance and practical readability. Another point featured is the fact that the characters are shaped so as to permit the cutting of sharp inside corners in minimum time. It is stated that, with this equipment, hand finishing is entirely eliminated. Side walls of any angle of 35 deg. or over, from center line, can be obtained by using a tracing stylus and cutter with corresponding angle.

For straight-line work, the characters are placed in standard beveled grooves, as with brass masters. For circular, curved, or angular arrangements, the back studs are engaged in a tapered groove which is cut into a plate or board to follow the desired alignment. When properly arranged, the characters are then cemented in place.

It is claimed that the use of a three-dimensional machine, with these masters, reduces by an average of 30 per cent the time required for production on a two-dimensional machine. Descriptive literature and samples will be furnished upon request to the manufacturer.

Vertical Presses

Vertical hydraulic presses have been developed by the Denison Engineering Co., Columbus, Ohio. They are styled "Type DLSC1" and are for straightening, forcing and general production pressing. A press cylinder assembly consists of finished steel cylinder fitted with nickel iron cylinder heads, piston and steel piston rod. Piston rod is sealed with self-sealing packing which is subject only to low pressure and piston is sealed with metal piston rings. Cylinder is flange-mounted in upper portion of the C frame. Control valves, their operating levers and motor starter are in the throat of press frame. Hydraulic pumps, driving motors and oil supply tank are in the base. A slot runs lengthwise through work table for positioning of dies or fixtures. Ram is guided against rotation by machined guides in throat of press. End of ram is topped concentric with the ram itself for holding tools or fixtures.

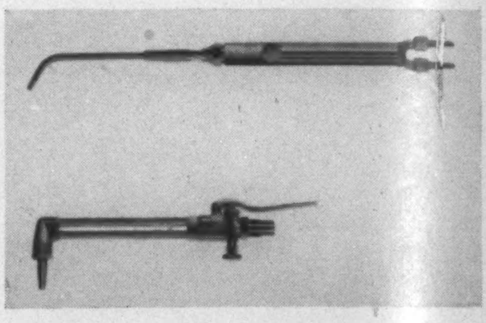
Press may be operated either by a conveniently located hand lever or by a foot pedal. Maximum tonnage exerted by ram can be adjusted from its full rated working capacity in infinite steps to approximately 10 per cent of its rated working capacity.

Welding Blowpipe and Cutting Attachment

A new medium-pressure oxy-acetylene blowpipe for welding light-gage metal, and a cutting attachment for cutting iron and steel up to 1 in. in thickness, have been announced by The Linde Air Products Co., a unit of Union Carbide and Carbon Corp., New York.

The blowpipe, known as the "Prest-O-Weld (Type W-109)" welding blowpipe, is claimed specially designed for welding in light production work and in aircraft construction. Its field of usefulness is said to include, however, all applications in which metals up to ⅜ in. in thickness are to be joined. Field tests have proved it equally well adapted for sheet metal welding, automobile fender and body work, radiator repair, and dental and jewelry work.

Because it is slender, light, and well balanced, it can be used over extended periods with a minimum tiring effect, and is extremely suitable for welding in hard-to-reach places. Both valves are conveniently located at the forward end of the handle where they can readily be adjusted by thumb and forefinger of the hand holding the blowpipe. "A" size, screw-type hose connections facilitate connecting and disconnecting the blowpipe. There are 8 sizes of welding heads for the W-109 blowpipe, each with an individual mixer. These individual mixers make the heads less sensitive to pressure fluctuation, extending their range so that fewer heads are required.



The "Prest-O-Weld (Type CW-109)" cutting attachment, for the cutting of sheet metal and light plate up to 1 in. thick, attaches directly to the W-109 blowpipe handle in place of the welding head. The combination of the W-109 and CW-109 is pointed to as forming an exceptionally useful, well-balanced unit. The attachment features an improved cutting valve with rubber-seated stem, and a cutting valve lever that can be turned back 90 deg. to permit ready access to the cutting valve assembly, and for easy connection to and disconnection from the blowpipe handle. Two cutting nozzles are supplied, the No. 0 which will cut iron and steel up to ¼ in. thick and the No. 1 which will cut up to 1 in.

Recovering Scrap Losses

A novel method of reducing scrap losses has recently been put in operation by the General Foundry & Mfg. Co., Flint, Mich., manufacturers of Meehanite brake drums for trucks and trailers. The system has given definite proof of its effectiveness by reducing scrap losses and stimulating interest on the part of the workmen in raising the standards of their output.

The device consists of a blackboard which contains the names of the molders, listed according to their number and is so ruled that a week's record may be kept. To the left of the board are two dog houses: One for each day, and one for a weekly record. Molders whose scrap returns exceed a predetermined percentage are placed in the dog house, much to their chagrin and to the amusement of their fellow employees. Those whose scrap losses remain in the lower brackets compete for a monthly prize of $30, divided among the six molders with the lowest percentage.

Colored red, white, and blue squares are used after each man's number to indicate the percentage classification into which he has fallen.

The board takes advantage of the human desire to excel and to avoid ridicule for inefficient workmanship. In operation, it has done much to improve employee relations as well as provide increased profits through reduced scrap losses.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

A Digest of
Important Developments
in the World of Metals

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1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

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3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

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5. General

Articles pertinent to more than one of the previous sections.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

1a. Ferrous

Hydrogen and Nitrogen in Molten Steel

A Composite

A concerted drive seems to be in progress throughout the world's steel-making plants to isolate and eliminate the sources of dissolved gases in steel. Two highly useful articles on dissolved gases have been published in recent issues of a Swedish journal, one on hydrogen and the other on nitrogen.

In the first of these S. von Hofsten, Bo Kalling F. Johansson & O. Knös ("Upp-tagning och avgivning af väte under stalprocessens förlopp," *Jernkontorets Annaler*, Vol. 123, No. 10, 1939, pp. 485-526) report a series of measurements, carried out in full scale furnaces, on the gas composition and the hydrogen content of molten metal during the steelmaking process. An inverted graphite crucible fitted to a water-cooled delivery tube was used for drawing off gas samples about 50 mm. below the surface. The graphite crucible remained intact for 0.5 to 3 hrs., depending on the condition of the slag and the carbon content of the steel.

Samples of the molten metal were analyzed for hydrogen by vacuum melting, and for carbon. The hydrogen content of the gas was found to drop as the carbon was burned out. This was assumed to be due to the diffusion of dissolved hydrogen into bubbles of carbon monoxide formed during the decarbonization process. On this assumption it was possible to derive an equation, $1/\sqrt{H_2} = 32\ (C_1 - C) + 1$, where H_2 is the partial pressure of hydrogen in atmospheres, and $C_1 - C$ is the decrease of the carbon content, which approximately reproduced the relationship between dehydrogenation and decarbonization.

If the furnace gas contains hydrogen or any of its compounds, the dehydrogenation is incomplete and reaches an equilibrium value. A reduction of 0.3% in the carbon seems to be sufficient to reach equilibrium even with high hydrogen content. The absorption of hydrogen is promoted by a high partial pressure in the gas, and partly hindered by a protective surface slag, but the rate of decarbonization seems to have no influence. Appreciable quantities of hydrogen may be absorbed through the use of partly slaked lime, moist ore or leaking doors.

In the comparison of various furnaces it was found that the electric furnace melts showed lower hydrogen because of the absence of hydrogen in the gases. The acid slags seemed more resistant to absorption than the basic open hearth slags, and the end gas compositions were respectively 1% and 2% H_2. In Bessemer and Thomas processes the hydrogen content reaches an equilibrium value dependent on the moisture content of the air used for blowing.

The solubility of nitrogen (oxygen-free) in molten steel was studied by Lennart Eklund ("Krävets löslighet i stål," *Jernkontorets Annaler*, Vol. 123, No. 11, 1939, pp. 545-555), who passed the gas into the melt through a Pythagoras tube. The composition of the steel was 0.03-0.04% C, 0.07% Mn, 0.01% P, 0.014% S, and traces of Si. The crucible was alumina, and heated in a high frequency furnace.

Samples were taken by dipping steel tubes (0.15% C) into the melt and chilling, or by ladling. A stream of nitrogen was maintained through the furnace during sampling to avoid contamination with air. Borings or turnings from the chilled sample were taken for analysis for carbon and nitrogen: Nitrides were determined by dissolving in dilute hydrochloric acid followed by distillation of ammonia with sodium hydroxide. Insoluble nitrides were filtered off and dissolved in concentrated sulphuric acid and sodium pyrosulfate.

The nitrogen content was 0.042% at 2800° F.; 0.043% at 3000° F.; and 0.044% at 3100° F. At 2800° F. the effect of carbon on the solubility was studied. Up to 0.05% C, the nitrogen content was 0.042%, dropping to 0.034% with 1% C, 0.022% with 2% C and 0.011% with 4% C. Aluminum has relatively slight influence on the nitrogen content, the increase in nitrogen being 0.002% for an increase of aluminum from 1% to 3%. The rate of saturation was found to be 100 min. at 2550° F., 60 min. at 2800° F., 50 min. at 3000° F. and 25 min. at 3100° F. Temperatures were measured by a Holborn-Kurlbaum pyrometer through a total reflecting prism. HCD (1a)

Large Steel Castings

"Application of Controlled Directional Solidification to Large Steel Castings." Joseph A. Duma & Stanley W. Brinson. *J. Am. Soc. Naval Engrs.*, Vol. 52, Feb. 1940, pp. 26-64. Extensive foundry practice research report.

Favorable temperature gradients imposed on molds containing liquid steel in amounts of 10,000 lbs. or more aid control of the direction of solidification. This, together with factors affecting design, the manner of metal handling, and molding technique can provide a casting as nearly perfect as possible.

A successful foundry technique developed at the Norfolk Navy Yard for large and intricately shaped castings consists of the following practice: (1) Employment of miniature models for a critical study of the proposed design prior to making the final patterns; (2) application as far as practically possible of principles of directional solidification; (3) mechanical relief of molds and cores after pouring; (4) use of synthetically bonded silica sand mixes in mold construction; (5) use of high quality steel; (6) constant and widespread use of gamma-ray for examination of internal structure of all critical sections.

The use of green sand molds, mechanical loosening of cope bars and tie rods, pulling out and relieving blocks, and breaking core crabs permit unobstructed contraction at high and low temperatures and prevent hot tearing. Synthetically bonded sand mixes consisting of washed silica, water and bentonite are remarkably resistant to damage by molten steel and are free from organic, gas-forming materials which are responsible for blows, pinholes and gas cavities. The balancing of the various physical properties of the sand mixes secured in practice by suitable tempering, ramming and drying will safeguard the casting against the remaining defects which include scabs, buckles, rough surface, drops, cuttings and sand inclusions.

An extensive tabulation of composition and physical properties for the mixes for various conditions of surface treatment, drying treatment, aging, and skin drying is given for steel molding and core sand mixes. Dry steel facing sands deteriorate rapidly with setting or prolonged exposure to air. This is the principal reason for the failure and burning down of the cope in anchor shank and anchor crown molds. Dry sand molds should be poured within 12 to 24 hrs. after drying. Green sand molds do not deteriorate with time, provided their surface is stabilized by torch-drying before closing up. Silica mold and core washes are to be used lightly and as sparingly as possible. They choke up cores and molds and thus obstruct the expulsion of whatever gases are generated within them. Spraying green sand molds with molasses water, and cores with linseed oil, does not harm either the physical properties or permeability.

The melting technique for the steel was developed to overcome porosity and low ductility, which are chargeable to insufficient deoxidation and overreduction. A basic electric furnace is used and melting is done under one slag resulting from restricted oxidation of the melt and finally under another slag consisting of strongly basic and highly reducing materials, the latter a product of several degasification and physicking reactions. Degasification in the fur-

CORE AND MOLD OVENS, FOUNDRY EQUIPMENT CO.

FOUNDRY SERVICE

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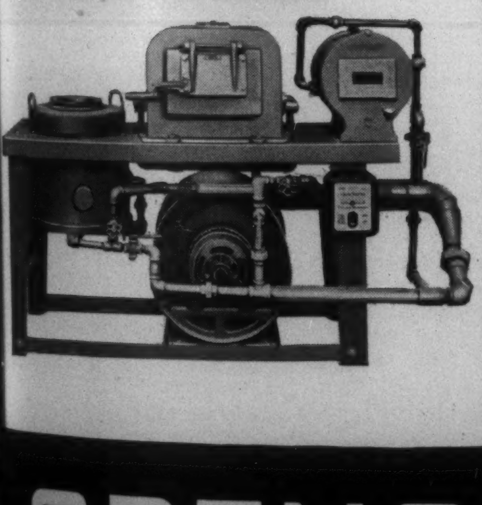
pencer Turbo-Compressors are consistent the economic factors so impor- in cupola and oven opera- . They have been repeatedly ommended by the leading ufacturers of foundry equip- t for more than a quarter of a ury.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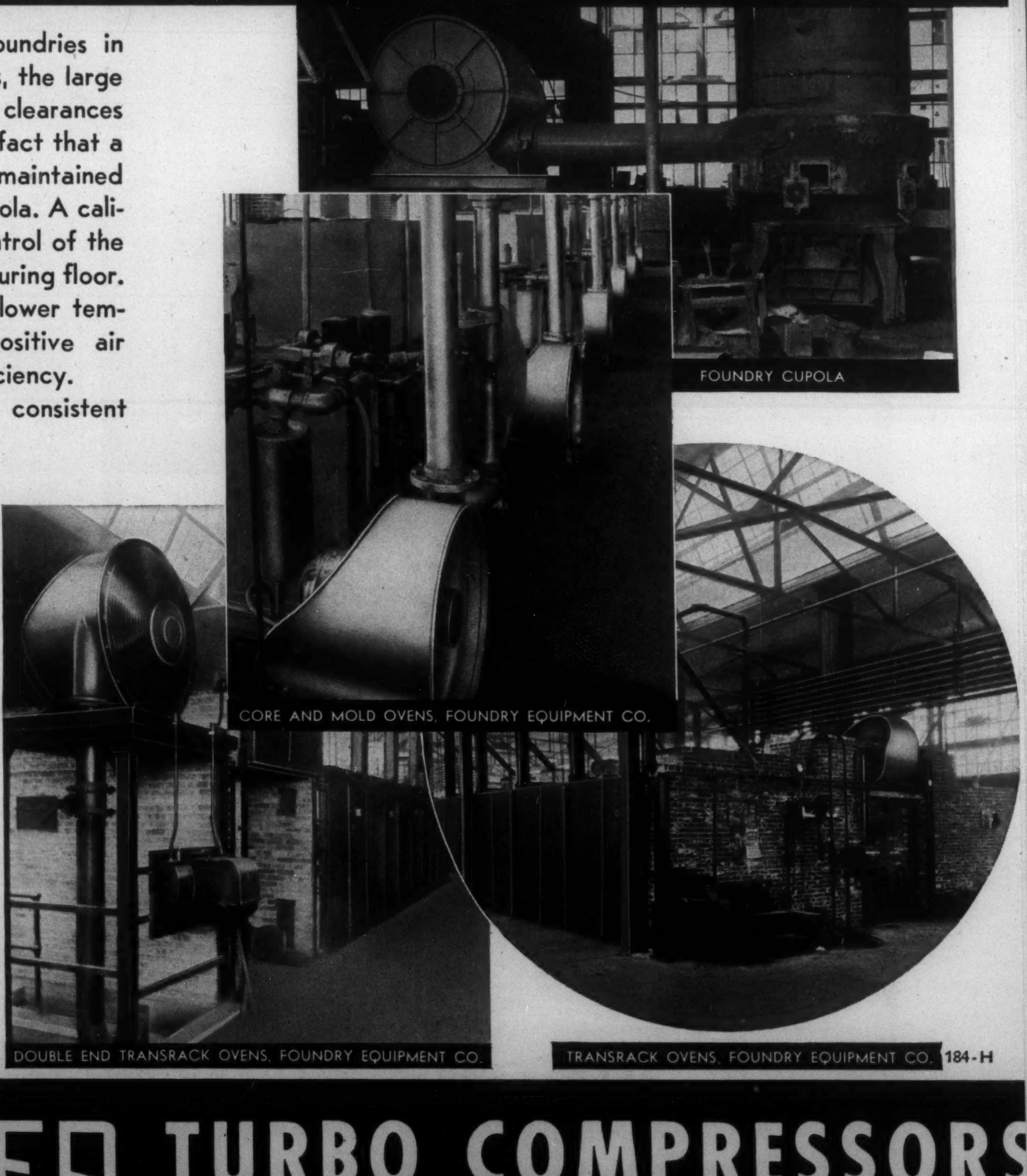
FOUNDRY CUPOLA

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nace is done with ferro-silicon, ferro-manganese and ferro-titanium, and again in the ladle with calcium-silicon. The refining slag contains a high starting percentage of calcium-carbide which is considered responsible for the efficient desulphurization.

Piping is eliminated or localized by efficiently feeding shrinkheads or risers, and other defects are minimized by means of directional solidification. Where practical difficulties prevent the establishment of a temperature gradient favorable to directional solidification, the following are suggested: (1) Banking or partial reversal, 20-45°; (2) top pouring of risers; (3) heading; (4) gating-parting, multiple and stepwise; (5) chilling, coring design; (6) padding-outside, inside, eccentric; (7) sectioning or partitioning of castings; (8) preheating the cope.

Specific cases of control of large castings by means of the 7 alternatives above, as actually practiced, are described. In one instance (a 20,000-lb. stockless anchor) the mold was banked 20° to bring the feed head into the requisite superior position in relation to the casting, thus effecting overall temperature gradients of 700°-900° F. in the shank. The additional steps taken to assure a steep temperature gradient are slow pouring, filling feed heads from the top, and heat-insulating the top of feedheads. The metal was poured at 2850°-2875° F. through a 2½-in. nozzle giving a pouring time of 25 sec. and a rise of 1 in./sec. for the metal in the mold.

Another case illustrates control by gating where top and parting-gating alone are effective in producing favorable temperature gradients. Bottom gating is most popular with foundrymen despite the adverse temperature gradients it creates. It is favored because it introduces metal into the mold with a minimum of metal and mold disturbance. The use of bottom-gating is illustrated in which 3 gates from a single sprue feed the casting at 3 levels in the same vertical plane and after casting, 3 risers are individually top-poured.

Directional solidification is further assured by producing a favorable temperature gradient in both the mold and metal by internal padding and placement of external metal mounts directly over the junction of each arm and the hub of the casting. Mechanical relieving is used to permit the casting to contract unhindered. Until this practice was developed considerable difficulty was experienced in obtaining good castings. The cast weight of the casting was 14,200 lbs., and finish-machined weight 7,140 lbs.

Another case—a low pressure turbine casing—illustrates control by chilling. The primary purpose of externally applied chills, as used today, is to eliminate adverse local temperature gradients set up at junctions of thin and thick sections, and at locations of extra mass (hot spots) found at positions of joining sections. The latter are the loci of stress concentration and hot tear formation. Several turbine cases are illustrated which have numerous V, X and Y joints, some very remote from the feed heads. The hot spot in each X joint was eliminated by means of 4 triangular chills. No chills were used on the V and Y joints, but the entire joint was tapered, the leg of the Y was spread, and the potential area of shrinkage caused to appear inside of the casing.

Another illustration—a throttle valve body—demonstrates control by sectioning. A complicated casting, in which it is impossible to direct solidification, is made in two or more sections and joined by welding. It is stated that the foundry recognizes welding not only for minor repairs of surface defects, but for construction of metal assemblies as well. The carbon-molybdenum steel castings were joined together and with carbon-molybdenum cladding by welding in flat position with 3/16 and ¼-in. dia. electrodes using a 45° bevel with a root spacing of ¼ in. backed up with a machined backing ring. Welding is carried out with a preheat of 300°-500° F., provided by oxyacetylene torch. All welded joints were X-rayed and stress-relieved at 1250° F. WB (1a)

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Blast Furnace Slags

The Influence of Silica, Titania and Alumina on the Viscosity of Acid Synthetic Slags and the Calculation of the Viscosity of Acid and Basic Blast-Furnace Slags from their Chemical Composition ("Der Einfluss von Kieselsäure, Titansäure und Tonerde auf die Zähigkeit einer sauren synthetischen Schlacke und Berechnung der Zähigkeit saurer und basischer Hochofenschlacken aus der chemischen Zusammensetzung") K. Endell & G. Brinkmann. *Stahl u. Eisen,* Vol. 59, Dec. 7, 1939, pp. 1319-1321. Original research, supplementing previous work.

Acid synthetic slags become increasingly viscous as the silica content is increased; at 50.4% SiO_2 the value for the viscosity becomes greater than the maximum viscosity at which blast furnace slag will still flow at 2750°F., namely $\eta = 75$ c.g.s.

Titanium oxide lowers the viscosity, at least up to 17.3% TiO_2, so that in smelting titanium-bearing ore no difficulties should be met because of slag viscosity. Increasing alumina raises the viscosity, and also the temperature at which crystals separate

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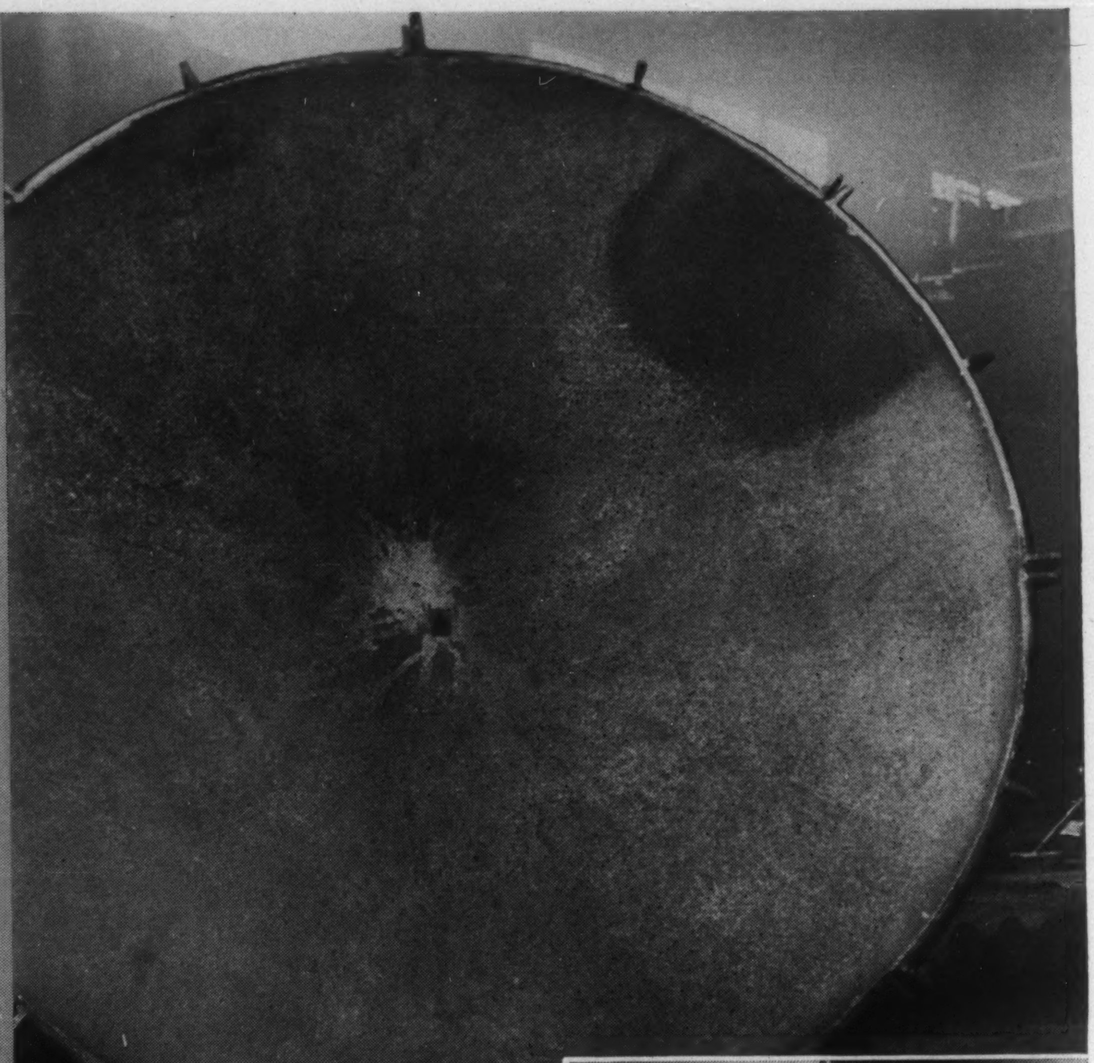

● Inside and outside views of 12-ft. annealing furnace cover of this steel works, showing Refractory Concrete lining, made with Lumnite. This job was done quickly and easily. No joints to leak heat. Plenty of strength to resist the hard knocks these covers get.

OPERATORS in this steel works lined their circular annealing furnace covers with Refractory Concrete. Result? A quick, low-cost job. A monolithic lining with no joints to leak heat . . . and with plenty of strength to resist the hard knocks these covers get day in and day out.

This steel works has used Refractory Concrete made with Lumnite for 5 years on annealer roof sections, door linings for core ovens and heating furnaces, tops of annealing cars —wherever they wanted to save time and money on refractories.

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4. Special shapes made in 24 hours. Precast shapes made as needed, cutting inventory expense.

What is Refractory Concrete? It's a special-type concrete combining high cold-strength with structural strength even after long exposure to high furnace temperatures. Refractory Concrete is made by mixing Lumnite—a heat-resistant binder—with refractory, heat-resistant, or insulating aggregates—their choice depending on the need.

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LUMNITE FOR REFRACTORY CONCRETE

out, the results here being in agreement with those obtained at Corby. A hyperbolic curve is shown giving the relation between the viscosity at 2750° F. and the chemical composition. SE (1a)

New Sheet Mill

"Three-High Jump-Type Sheet Mill." R. J. Leckrone (Lewis Foundry & Machine Co.) *Can. Metals & Met. Inds.*, Vol. 3, Feb. 1940, p. 50. Descriptive.

A new 3-high jump-type roughing sheet-bar breakdown water mill at the Algoma Steel Corp., Ltd., Sault Ste. Marie, Ont., has many interesting features. One of these is a 10 to 1 ratio single-reduction herringbone drive, driven by a 600 hp. motor and estimated to increase the plant's breakdown production approximately 50,000 tons annually. This, with automatic roller and catcher tables, permits this mill to roll 70 tons per 8-hr. turn.

The sheet or "tin bars" are heated through a continuous gas-fired furnace at 1550° F. and are delivered to the mill in pairs, to be given 2 single passes and 3 matching passes, or a total of 5 passes per pair. The maximum thickness of bar on the jump-type mill is 5/8 in., which can be rolled down to about 1/16 in. in thickness in 5 passes.

The mill will be equipped with hand-operated screwdown, consisting of spanner wheels and operating lever. The bottom roll only will be driven through a universal type spindle to eliminate the drag. The roll speed will be approximately 30 r.p.m. The middle roll and top rolls depend for their rotation on friction. The top and bottom rolls will be equipped with water-lubricated fabric bearings, and the middle roll with anti-friction roller bearings.

Certain new mechanical features have been incorporated on the new jump-type mill that permit changing of the middle roll in 4 min. This is unusual for a jump mill. With the new design, it is not necessary to remove spindles, spindle carrier or drags in order to change the bottom roll; consequently, the changing of all 3 rolls is accomplished in less than 40 min. WHB (1a)

1b. Non-Ferrous

Non-Ferrous Casting Defects

"Avoiding Defects in the Non-Ferrous Foundry." N. K. B. Patch. *Foundry*, Vol. 67, Dec. 1939, pp. 31-32, 110, 112; Vol. 68, Jan. 1940, pp. 35, 88, 90; Feb. 1940, pp. 29, 97-101; Mar. 1940, pp. 33, 102, 104, 106, 107. Practical.

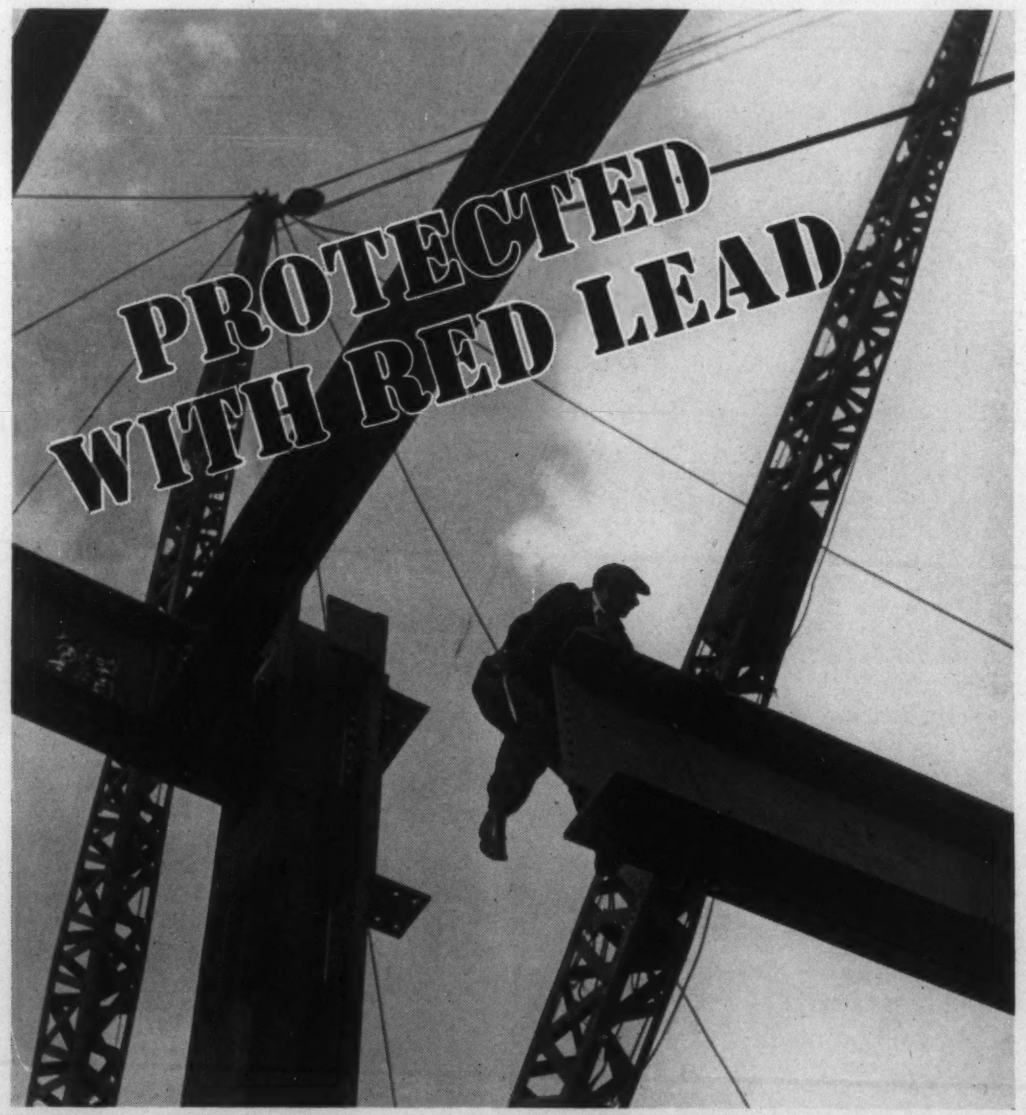
Defects in non-ferrous castings may be due to design or to variables in the processes of preparing molds, melting and casting. Some engineers, in order to economize, reduce the wall thickness or cut down on the machining allowance. A happy medium exists between designing castings with a very thick wall and with a wall excessively pared. Adequate fillets should be provided where thick and thin sections join together, and the changes from thin to thick sections should be gradual.

Metal coreboxes are preferred and should be designed to lend themselves to rapid production of cores. Pattern equipment should be considered carefully in relation to the number of castings to be made, the alloys that are being used, and the influence that equipment may have on defects. Shrinkage cavities appear where patterns do not permit location of risers. Blowholes occur if proper venting is not provided, or where corebox construction prevents uniform ramming of sand. Other types of defects may also be traced to pattern equipment.

Many non-ferrous alloys readily lend themselves to the production of good castings where the metal enters the mold at a low point and runs uphill. Gating is one of the major elements in production of good castings. Where casting has to be fed after it is poured, provision should be made for proper location of risers and their connections. Excessive shrinkage is the most common fault caused by improper gating. In yellow brasses the gates may cause smoke spots, while in aluminum and silicon bronzes they cause scum spots. These gates produce a spraying effect, and the metal sprayed into the mold cavity develops an excessive amount of surface oxide which must be knitted into the casting and flowed to the surface.

Inadequate risers will cause improper feeding and therefore internal shrinks. Round risers are preferred to square—because the surface area is much larger in square risers. Misshapen or badly constructed sprues may cause washing of the sand by the fluid metal.

Defects caused by bad molding practice include scabs, blowholes, etc. Swollen castings may result from over-rapping of the pattern to withdraw it from sand. Proper flask equipment enables the mold to retain its shape under all stresses. Bad venting of the mold results in blowholes or similar defects. The choice of molding sand plus binder depends upon the type of work to be done. Defects directly attributable to molding sand are sand spots and scabs. No. OO Albany sand is most used because it is finer and gives a better surface finish. If the gas pressure in the mold is great, the gases will force their way out of a poorly vented mold. If the pressure is low, a poor-



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(Left) Brown Potentiometer Pyrometers controlling temperatures of pickling tanks and (Above) two of the five Brown Analy-Graph Furnace Atmosphere Recorders installed in the Middletown Plant.

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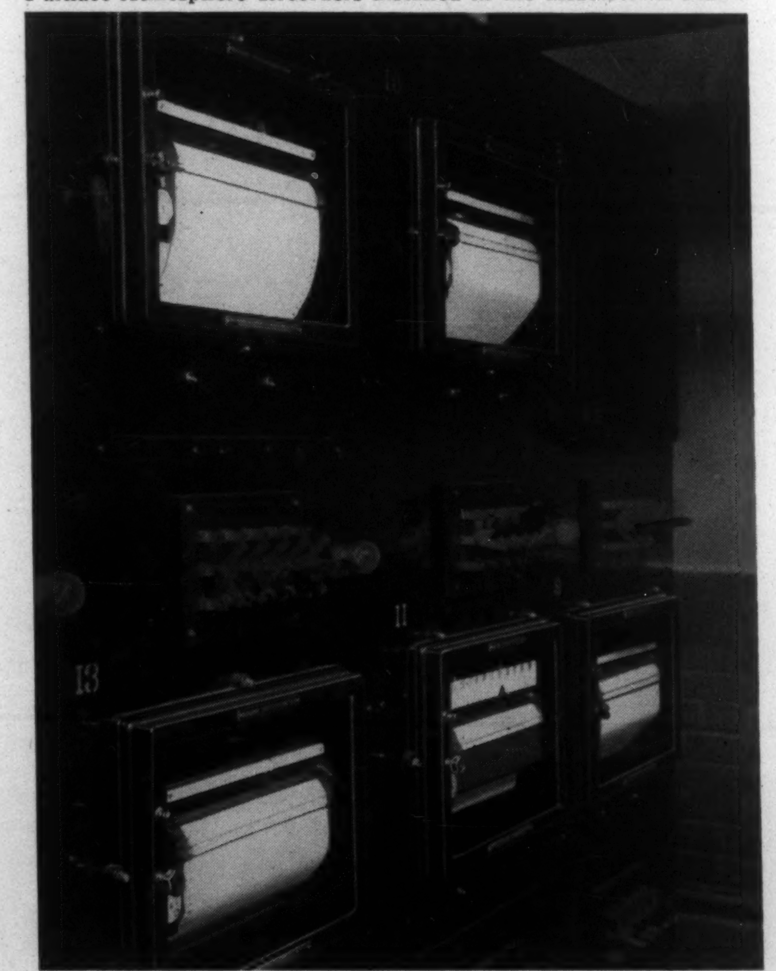

Brown Potentiometer Pyrometers controlling temperatures of Annealing Furnaces

BROWN POTENTIOMETERS
AND
MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS

To Measure and Control is to Economize ly vented mold may resist flow of gases and they may be forced into the metal, causing blowholes.

Coreboxes that make it difficult to ram sand uniformly may result in soft spots in cores. A core removed with difficulty often causes unseen cracks. Improper finish of a core may cause poor surface on the cored face of casting. This often results in burned metal or a sand-locked surface that is impossible to tool. Cores of large dimensions are made with a thin wall of fine sand to form a smooth surface, backed with coarser sand, and finally backed with open material, coke, gravel, etc., thus providing free venting and easy crushing at solidification. Dry sand is bonded to hold it together. Many cores are coated with a heat-resistant material to increase their smoothness, and these coatings often are the cause of defective castings, especially when badly applied.

However perfect the mold, improperly melted metal may end up as a defective casting. Proper melting includes not only prevention of gassing but also prevention of contamination by unwanted material. Often iron from iron pots dissolved in molten non-ferrous alloys reduces the physical properties of the metal. Another source of contamination is from iron stirring rods, although this may be avoided by using graphite rods. Defects are often caused by improper pouring into the mold, and therefore the sprue should be located where the ladle mouth can be brought to it conveniently. The metal should be poured as fast as the sprue will take it and still be kept full. Gating should be such that, with a full sprue, the flow of metal into the mold is sufficiently rapid to fill the mold satisfactorily, yet not so fast as to cause nozzle effect or tearing of the mold, and washing of the cores or mold. Pouring at a definite temperature means pouring in sufficiently small quantities so that the loss in temperature is not sufficient to cause a serious error.

Certain non-ferrous compositions have their own peculiar defects. For instance, scum spots are produced in castings made from aluminum or silicon bronzes, or in other compositions in which aluminum and silicon are present in sufficient quantities to produce a soapy effect—foaming of the alloy, with the formation of scum. Where the metal enters the mold as a jet, the formation of oxide film over the surfaces developed in this jet causes excessive scum. This condition may be corrected by a gating system that allows the metal to enter the mold quietly and steadily, and by pouring without breaking the stream or carrying air in with the metal, and without such force as to disrupt or break the film around the metal with the mold.

High-lead bronzes with 10-50% Pb have their own defects, such as lead segregation and sponginess. Deoxidation is best accomplished with phosphorus, tin or phosphor-copper. The presence of nickel in the high-lead alloys raises their melting points; the matrix sets at a higher temperature during cooling and forms a sponge to hold the lead in place, or in other words, prevents segregation. There are, of course, other methods of preventing segregation.

Cupric oxide as a segregation-reducing component of the lead bronze composition is not sufficiently recognized. Some manufacturers use a fluxing reagent to increase the amount of cupric oxide in the composition. A number of fluxes may be used for this, such as barium sulphate. Too much copper oxide, however, may result in the formation of tin oxides and lead oxides. The presence of lead and tin oxides in excess tends to make the composition sluggish when pouring the castings. To avoid this, deoxidation must be done by use of the right amount of phosphor-copper — too much may lead to segregation, and too little to sluggish pours.

In casting a yellow brass containing aluminum, the excess aluminum will tend to increase the amount of scumming spots, which are not polished away in buffing. Excess aluminum may also cause folds that cannot be polished out. The aluminum should be maintained at the lowest figure that will produce the desired results—a strong, protective envelope around the metal as it expands to fill the mold cavity. Folds are not always caused by aluminum, but may result from poor gating and pouring. The presence of aluminum or silicon in yellow brasses is generally considered to cause poor resistance to leakage pressure. Also, castings that have not been fed properly are prone to leak under pressure after they have been machined. VSP (1b)

Aluminum-Silicon Alloys

THE EFFECT OF VARIOUS ADDITIONS ON THE CRYSTALLIZATION OF EUTECTIC ALUMINUM-SILICON ALLOYS ("Wirkung verschiedener Zusätze auf die Kristallisation von eutektischen Aluminium-Silizium-Legierungen") G. GÜRTLER & E. SCHULZ. *Giesserei,* Vol. 26, Nov. 3, 1939, pp. 537-543. Research.

Eutectic aluminum-silicon alloys possess, like cast iron, a high castability. Their mechanical properties can be improved by adding sodium or sodium-containing salts, according to the discovery of Pacz, to give a finer grain structure. The effect of sodium additions when still other elements are present was investigated.

If too much sodium is added, coarse sili-

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con crystals are precipitated, and a ternary aluminum-silicon-sodium eutectic may be formed. Tensile strength and elongation increase with increasing amount of sodium addition, but too much should be avoided, for a high sodium content favors the formation of oxide films and foamy inclusions in castings. Ordinary silumin contains as an unavoidable impurity 0.3-0.5% iron in the form of a tetragonally crystallizing crystal Al_4Si_2Fe. On etching a specimen that contains too much sodium, these crystals can be seen, not in the ternary eutectic, but as coarse, primary crystals. They have a deteriorating effect on strength, but this can be counteracted by the addition of about 0.3% manganese, which changes the plate-shaped crystal into one of dendritic shape which is mechanically practically harmless.

The addition of magnesium forms Mg_2Si, which, if sodium be present in aluminum-silicon alloys, accumulates during slow solidification at the boundaries of the binary eutectic zones and forms the ternary eutectic Al-Si-Mg_2Si. This eutectic has a 25° C. lower solidification point than the binary eutectic and appears in the form of veins between the binary eutectic zones. The veins have a greater hardness and have an undesirable effect on machinability, which can be eliminated most effectively by increasing the rate of solidification. The effect of copper is similar to magnesium and again, is noticeable only in alloys with sodium additions. A ternary eutectic Al-Si-$CuAl_2$ is formed, which is located also at the boundaries of the binary eutectic zones.

Addition of titanium to aluminum-silicon leaves the binary aluminum-silicon eutectic unchanged but increases the number of crystallization nuclei of the solidifying aluminum solid solution considerably. About 0.3% titanium is required for this effect. Zirconium (about 1%) has the same grain-refining effect as titanium. While addition of sodium makes the primary silicon coarser and the eutectic silicon finer, the addition of phosphorus causes a finer and more even distribution of the primary silicon and makes the eutectic coarser. Addition of 0.2% phosphorus pentachloride makes such alloys particularly suitable for sliding bearing surfaces because of the better distribution of the harder crystal. Ha (1b)

Shrinkage During Casting

A Simple Method for Determining Metal Shrinkage During Casting ("Eine einfache Methode zur Bestimmung der Metall-Schwindung beim Giessen") J. Leuser. *Metallwirtschaft*, Vol. 19, Jan. 26, 1940, pp. 77-79. Descriptive.

The metal is melted down in a small crucible from which it is centrifugally cast into a permanent mold, giving a casting that is sound and of good quality. A 16-mm. hole in the permanent mold is filled through a 3-mm. slit from the crucible. Measurement of the hole and the cast disk enables one to calculate linear shrinkage.

The shrinkage measured is that from the solidus point to room temperature, as the outer portions of the disk are immediately solidified in the steel mold and all shrinkage takes place towards the center. Results obtained by this method compare favorably with dilatometric measurements of shrinkage, *e.g.*:

Metal	Dilatometric measurements	Centrifugal Casting Process
Gold	1.78%	1.80%
Silver	1.90%	1.97%
Copper	1.95%	1.99%

Experiments on a palladium-silver alloy (Palliag M) indicated that superheating as much as 250° F. had no influence upon shrinkage. GA (1b)

Solidification of Copper Alloys

"The Influence of Alloying Elements on the Crystallization of Copper. Part II.—Large Additions and the Part Played by the Constitution." L. Northcott. *J. Inst. Metals*, Vol. 65, 1939, Advance Copy No. 857, 32 pp. Original research.

The tendency toward columnar crystal growth of alloys representing the binary systems of copper with aluminum, magnesium, manganese, nickel, phosphorus, lead, tin and zinc was studied. The alloys were cast into a heated cylindrical mold set on a cold plate so that uni-directional solidification was obtained. In many instances it was found possible to correlate the length of columnar crystals with the constitution of the alloys.

In general, alloys that freeze at a constant temperature form wholly columnar crystals. The presence of a freezing range of any size tends to reduce the formation of columnar crystals, although the different alloy systems behave differently in this respect. The presence of a second phase may either increase or decrease the length of columnar crystals, depending on the type of constitution; the significant point is that the greater the freezing range, the more equiaxed (less columnar) will the structure be. The structures of a few ternary and more complex alloys are considered.

JLG (1b)

Case #419

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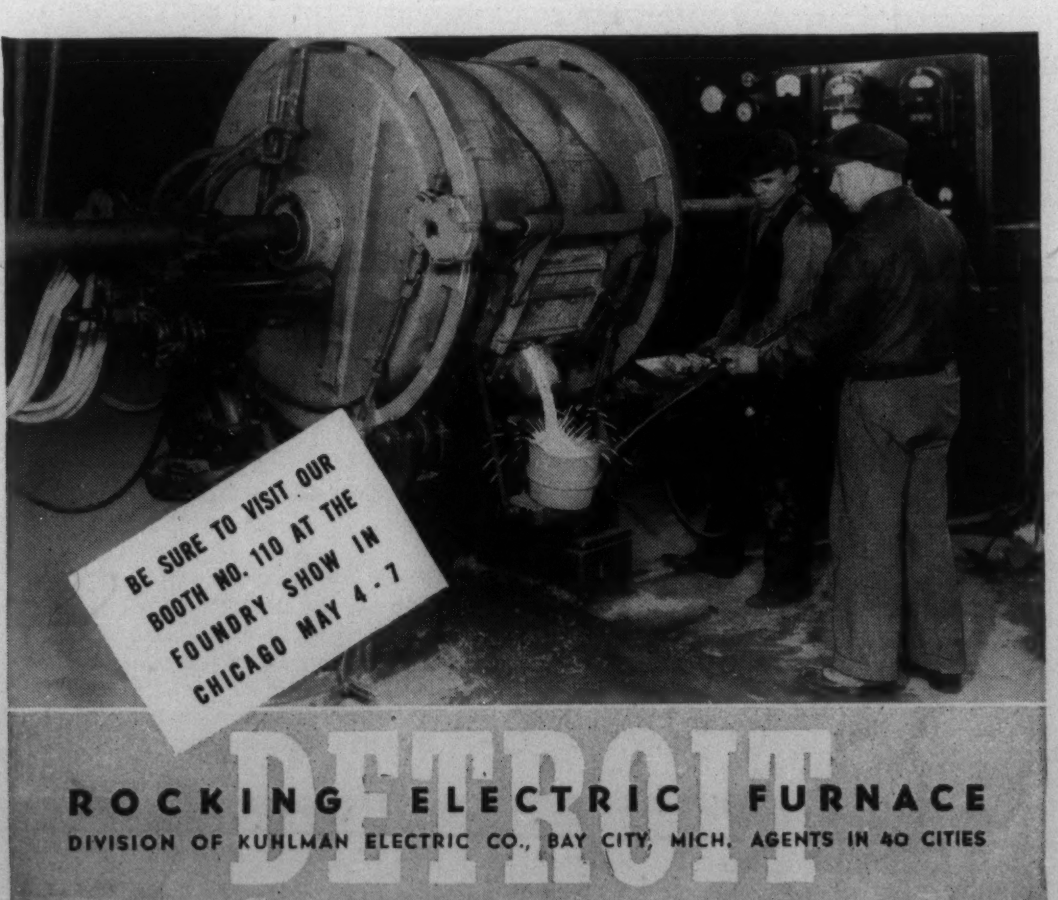

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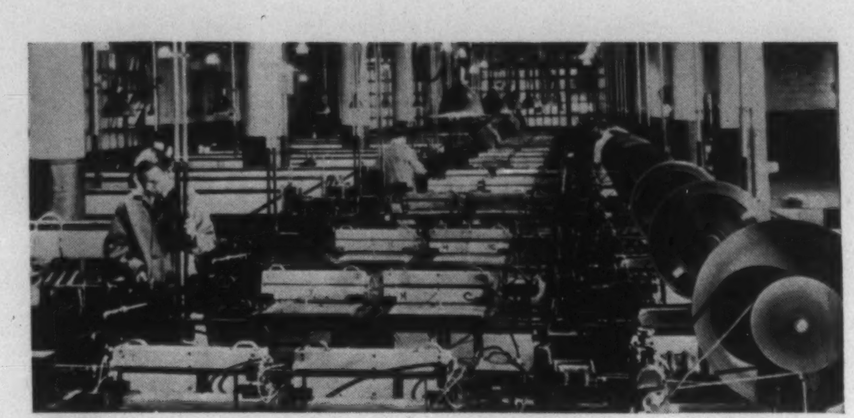

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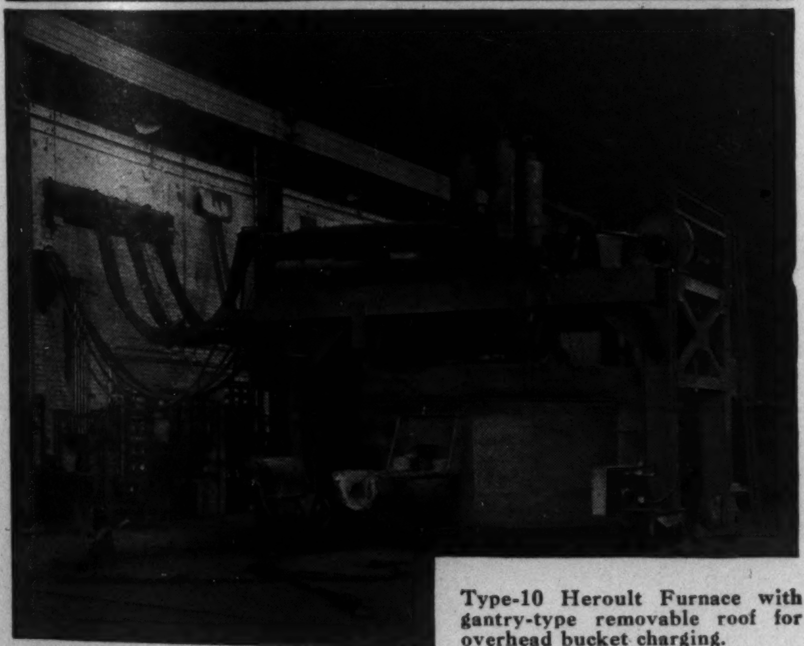

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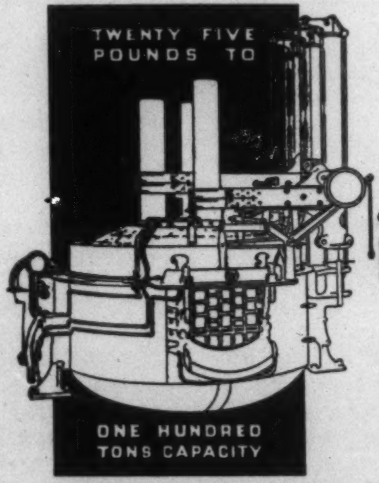

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Underwater Cutting Arc-Cutting and Oxygen-Cutting

"Underwater Cutting, Arc Cutting, the Oxygen Lance, and Oxygen Deseaming and Machining. A Review of the Literature to Jan. 1, 1939." W. Spraragen & G. E. Claussen (Welding Research Committee) *Welding J., N. Y.*, Vol. 19, Mar. 1940, pp. 81-s—96-s. Correlated abstract. 164 references.

The distinguishing characteristic of underwater cutting torches is the tip. Besides the customary oxygen nozzle and concentric holes for preheating the gases, the tip is made to provide a shield for combustion. If the flame is not surrounded by a gaseous sheath, the heat cannot be localized because water has a thermal conductivity about 40 times greater than air.

Compressed air has often been used for shielding. The tip consists of 3 overlapping, concentric nozzles. This construction can be made extraordinarily light, a torch weighing only 2.5 lb. The compressed air pressure should be 1 lb./in.^{2} for every 2 ft. of depth, according to several writers. An initial pressure of 10-15 lb./in.^{2} may be added to the calculated pressure. Ordinarily, the oxygen supplied to the underwater flame is the full amount required for complete combustion; this is in contrast with torches for use in air, to which only a part of the required oxygen is supplied, in order to secure maximum flame temperature.

One investigator, adapting his observation that an oxyacetylene torch will not be extinguished if it is lowered into the water with the flame pointed upward, utilized the products of combustion to sheath the flame. The protecting chamber is such that the walls of the chamber are tangential to, or make contact with, so as to compress slightly, the exterior of the jacket of products of combustion surrounding the flame. The material to be cut is 0.12-0.20 in. beyond the end of the chamber. To insure complete combustion excess oxygen may be added to the preheat gases or fed to the chamber. To protect the tip from overheating during heavy cutting an inert gas may be supplied to the chamber. The water does not affect the flame and the torch may be lowered into the water in any position. In the operation of the oxy-hydrogen underwater cutting torch with a jacket of burnt gases, one investigator found that successful oxygen and hydrogen pressures were directly proportional to depth up to 100 ft. When the color of the oxyacetylene flame changes from blue to orange during preheating the steel is ready for the oxygen jet. Each of these types of torches generally requires different pressures for optimum conditions.

The speed of underwater cutting appears to depend largely on visibility and other working conditions, and on the type of torch. Sixty ft./hr. can be maintained on steel ⅜ in. thick, which is somewhat slower than manual cutting in air. So long as combustion is too rapid for the quenching action of the water to be effective any fuel can be used. Acetylene is satisfactory in shallow water up to 25 or 50 ft. but is unsatisfactory in deeper water on account of back firing. Since acetylene is satisfactory only in shallow water, underwater torches for deep cutting are nearly always operated with hydrogen.

Developed about 1915, the oxy-electric underwater torch utilizes an arc to heat the metal and to provide a jacket of gas around the oxygen jet or jets, which issue from the hollow electrode. The oxy-electric torch is applicable to any depth, is relatively simple and rugged, but is slow and must be replaced at relatively short intervals. On account of reduced shock hazard, d.c. is preferred to a.c.

Arc welding underwater is more difficult than in air chiefly because the arc is less stable and visibility is poor. Good welds were secured with two commercial covered electrodes, one of the organic type, the other of the mineral type. Special alloys have been arc-welded underwater. Underwater gas welding is not as yet commercially successful. Seam welding sometimes is performed with the parts underwater.

The cutting of metals with the electric arc is performed by drawing an arc between the cutting electrode—which may be carbon or metal—and the metal to be cut. The arc is a concentrated source of heat and brings to the melting point only that part of the metal that is in the immediate vicinity. The metal is removed from the kerf principally by melting, although partial oxidation of the metal also plays a part. For carbon-arc-cutting, graphite electrodes are preferable. To cut material up to ½ in. thick the electrode is held at the edge until melting has begun. The electrode then is advanced, the arc is directed on the metal at the end of the cut and the end of the electrode is in the groove. Slanting the electrode backward so as to undercut is good practice.

The speed of arc-cutting mild steel as a function of plate thickness decreases from 75 ft./hr. for plate ¼ in. thick to less than [illegible] ft./hr. for plates 1 ft. thick. Cutting speed can be increased by increasing the current. The arc voltage varies from 25 to 45, but may rise to 65 v. at 1500 amp., which is the limit of practical arc cutting. The carbon electrode should be negative, otherwise it is difficult to control the arc and the electrode becomes blunt. The electrode also becomes blunt if a.c. is used instead of d.c., the cutting speed being only about 80% as great with a.c. as with d.c. Quoted values of kerf width in ½ in. plate vary from ½ to ⅝ in. at 250-300 amp., to ¾ in. at 500-650 amp. The process is mainly restricted to scrap cutting and rivet cutting.

Covered electrodes may be used for arc-cutting. The heat is more concentrated than in carbon-arc-cutting, the kerf being correspondingly narrow. Special covered electrodes for cutting whose coverings liberate oxygen are on the market. An electrode 1/16 to ⅜ in. in dia. covered with carbon to form an alloy of low melting point with iron has been used for rivet removal. A rotating mild steel disk 43 in. in dia., known as the arc saw, was used not long ago for arc-cutting. Teeth on the edge of the disk, whose speed is 390 ft./sec. act as one pole of an arc, the other pole being the metal to be cut. Between teeth the air oxidizes or burns the crater, and a spray of metal droplets is formed. The voltage is 8-15 and the power may be supplied by an a.c. 35 kw. transformer. Unlike oxygen-cutting, arc-cutting (carbon or metal electrode) is applicable to practically all metals. The cutting speed and power seem to vary with the melting point (heat content, thermal conductivity) and arcing characteristics of the metal to be cut.

Oxygen machining may be performed with cutting torches. The rate of metal removal in oxygen machining may be 600 to 900 lbs./hr. Oxygen consumption is 3 ft.^{3}/lb. The principal applications are planing and shaping, and cuts are designated as flat or oval, depending on profile.

CEJ (2)

Cleaning Methods and Adhesion of Electroplates

"The Adhesion of Electrodeposits." Frank C. Mesle (Oneida Ltd.) *Proc. Am. Electroplaters Soc.*, 1939, pp. 152-168. Original research.

The relative adhesion of electrodeposits to the base on which they were deposited was determined by measuring the pull required to peel them from the surface. To furnish a grip for the thin electrodeposits, their surface was plated with a coating of silver 0.005 in. thick, one end of which could be lifted from the surface and inserted in the testing machine.

The effect of various cleaning and plating procedures on the adherence of electrodeposits was studied. The adhesion of electrodeposits was highest on smooth-buffed surfaces and lowest on scratch-brushed or emeried surfaces. Heating after deposition usually improved the degree of adhesion.

Adherent deposits on stainless steel were obtained by following the cleaning cycle with a cathodic treatment in 10% hydrochloric acid and then immediately transferring the metal to a hot copper or silver strike or to a cold nickel strike. The best adherence of electrodeposits to cold-rolled steel was obtained with a hot copper strike. The adherence of nickel directly on steel was improved if no current was used in the alkaline cleaning.

The adhesion of silver and nickel to britannia metal was increased by heating to 350° F. for 10 min., but the adhesion of copper was reduced. There was no difficulty in obtaining good adhesion of nickel or silver coatings to base metals of "nickel silver," copper, or brass. If a silver strike were not used as a preliminary step to silver plating, the adherence of the silver coating was low. The adhesion of silver, nickel or copper coatings to lead was lowered if the surface were scratch-brushed before plating to remove discolorations produced in the cleaning procedure.

The adherence of cadmium on steel and of tin on steel was rather low, but this might have been due to the low tensile strength of the coating metals. AB (2)

2a. Ferrous

Welding Electrodes for Steel

A Composite

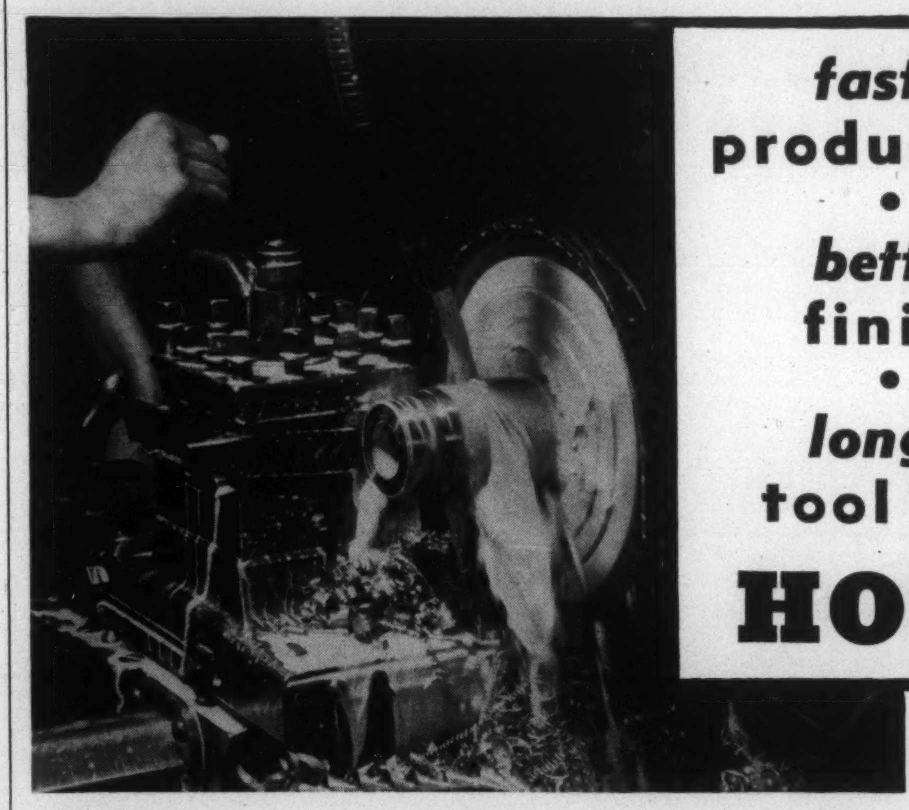
Electrodes for welding steel aren't "just electrodes" any more. Engineers are fast recognizing that the nature of the filler metal is certainly no less important in producing good welds than is the welding process, the type of equipment or the welder-technique. Even among "low-carbon steels" there are differences in carbon content, manganese content, finish, thickness, etc. that necessitate engineering judgment in selecting electrodes. The type of joint and the welder-technique must also be considered when deciding what type of electrode—analysis, coating, thickness, etc.—should be used.

Then, when we consider the many types of carbon and alloy steels that are welded today and the rigid engineering specifications on weld properties that must be met, we realize why the choice of filler metal in any case has become a metallurgical engineering problem. Three recent articles on electrodes emphasize the relation between careful electrode selection and weld properties, describe a new type of electrode for welding high-sulphur steels, and evaluate the behavior of coated electrodes as welding rod for gas-welding boilers.

Analysis of the electrode and nature of the electrode coating are important in arc welding steel, according to J. H. DEPPELER of Metal & Thermit Corp. ("Welding Electrodes and Their Applications," *Iron & Steel Engr.*, Vol. 17, Feb. 1940, pp. 32-46, 63). Electrodes for welding iron and steel consist of mild steel core wires covered with a carefully chosen mixture of mineral oxides and silicates, with or without a percentage of combustible material, all selected as to analysis and particle size so as to: (1) vaporize or burn, and thus yield the materials being transferred across the arc from the oxygen and nitrogen of the atmosphere; (2) offer sufficient resistance to fusion to create and maintain on the end of the electrode a symmetrical and inverted crucible neither too deep nor too shallow; (3) furnish to the arc materials to control its resistance and voltage and to stabilize the arc causing it to operate smoothly without wandering or spatter; (4) to supply those mineral oxides and silicates that will produce on vaporization and subsequent solidification a complete dark spongy (for lightness) slag blanket, capable of completely excluding the gases of the atmosphere, and subsequently of being easily cracked and brushed away.

A popular core material for ferrous electrodes is a high-grade rimmed steel, analyzing 0.13-0.18% C, 0.40-0.60 Mn, 0.06 Si, 0.04 max. S, 0.04 max. P. Carbon and manganese have a strong effect on the tensile strength of the weld metal. Elements such as molybdenum, nickel, vanadium, copper, chromium and tungsten are frequently employed in electrode design, and may be added either through the use of alloy core wires or through the coating. Weld metal tensile strengths as high as 100,000 lbs./in.^{2} combined with elongations of over 20% in 2 in., or as low as 63,000 lbs./in.^{2} with ductilities over 40% can be obtained. Other combinations are used to influence the hardness, corrosion resistance, cavitation resistance, creep strength, low-temperature impact values and resistance to fatigue of the weld. Sulphur content is important where perfect weld soundness is required.

Although the sulphur content of the electrode can be controlled to prevent unsound welds, the sulphur content of the parent



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metal may not be susceptible of modification by the welding engineer. Attempts to weld high-sulphur low-carbon steels often result in blow holes in the finished weld. However, tests by J. H. HRUSKA of Electro-Motive Corp. ("Welding High-Sulphur Steels," *Steel*, Vol. 106, Feb. 26, 1940, pp. 40-44) show that the use of a high-manganese welding electrode gives good manual or automatic arc welds in high-sulphur, high-manganese steels. In one case, a steel containing 0.15% C, 1.27 Mn, 0.014 P and 0.224 S, in the form of $2\frac{3}{4}$-in. plate, was successfully welded using a 1.10% Mn electrode. In hand welding, a 1.48% Mn electrode was used.

The welds were "practically perfect." Analysis of the automatic weld showed, in the heat-affected zone and in the weld metal, respectively: 0.15 and 0.15%C, 1.22 and 0.96 Mn, 0.02 and 0.26 Si, and 0.209 and 0.158 S. In another case, "X1515" steel containing 0.17% C, 1.21 Mn, 0.02 Si and 0.258 S, the properties of the high-manganese weld metal were 58,200 lbs./in.^{2} tensile strength, 45,650 lbs./in.^{2} yield point, 28.2% elongation in 2-in., 39.3% reduction in area, 121 Brinell hardness, 48.6 ft.-lbs. Charpy impact value, and bend test "O.K."

An interesting study of the suitability for *oxyacetylene* welding (of boilers) of several types of heavily-coated *electrodes* as compared with conventional welding rods has been made by R. WEIDLE ("Untersuchungen über die Brauchbarkeit von im Handel befindlichen Schweissdrähten und Elektroden für Schweissverbindungen im Kesselbau unter Verwendung der Acetylen-Sauerstoff Flamme," *Forschungsarbeiten auf dem Gebiete des Schweissens und Schneidens mit Sauerstoff und Acetylen*, No. 14, 1939, pp. 14-42). Eleven types of German commercial welding rods and eleven types of heavily-coated electrodes were employed as filler metal for oxyacetylene welding boiler steel plates 0.060 in. and 0.10 in. thick. The steel contained 0.08-0.12% C, 0.20-0.35 Si, 0.46-0.49 Mn, 0.01 S and 0.01 P.

The results of bending, hardness and notch impact tests on samples taken from different parts of the welded section, as well as microscopic examination, prove the excellent suitability of coated electrodes to such work. The bending angles of the electrode-welded plates on the average were better than those of welds made with uncoated welding rods. The values of notch toughness differ widely. Non-normalized electrode-welded samples showed weld-parting to the smallest extent. However, normalizing brings about a much larger increase of breaks at the weld with the electrode-welded than with the rod-welded samples. Most of the non-annealed rod-welded 0.10-in. samples possessed insufficient notch toughness, whereas the same material welded with coated electrodes possessed excellent notch toughness values. Evidently, in gas welding as much as in arc welding, coated rods are superior to uncoated. X (2a)

Deep-Drawing Alloy Steels

DEEP-DRAWING EXPERIMENTS WITH SHEETS AND STRIPS OF ALLOY STEELS ("Tiefziehversuche an Blechen und Bändern aus legierten Stählen") A. POMP & A. KRISCH. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch., Düsseldorf,* Vol. 22, No. 3, 1940, pp. 19-34. Research.

Fifteen steels were studied to learn whether their deep-drawability could be improved by heating them to 400° F. during drawing. The steels included 18/8 chromium-nickel steels; 15/15 chromium-manganese steels, some with high silicon; chromium steels with 6-18% Cr—some with up to 1% Mo or 1.32% Si; a carbon steel with 0.11% Mo and 0.04% C; and silicon steels with up to 4.22% Si and less than 0.10% C.

Inasmuch as few can agree on the respective merits of the various deep-drawability tests available, the authors tested their sheet (cold) by all four of the best-known methods: Erichsen; Siebel and Pomp hole-widening; wedge-drawing; and cup-drawing. No agreement was obtained between the wedge-drawing and Erichsen tests. Agreement was better between the Erichsen and Siebel-Pomp tests, and was best between the Erichsen and cup-drawing tests.

The cup-drawing test was employed for studying the effect of temperatures up to 400° F. on deep-drawability. In only one case—18% Cr, 1% Mo steel—was deep-drawability better at room temperature than when heated; the difference was slight, however. Only 5 of the 15 steels can be considered as satisfactorily deep-drawable at room temperatures, and of the others, 6 were drawable only at the highest drawing temperatures tested.

A 6% Cr steel and a silicon steel (1.64% Si, less than 0.01 C) gave the best results; cups could be drawn from discs of 55 and 66 mm. dia. at either 65°, 200° or 400° F. Raising the silicon content makes heating essential, however, for a steel with 3.38% Si could not be drawn at 65° F., and even at 200° F. cracks appeared, but at 400° F. perfectly satisfactory results could be obtained. Ha (2a)

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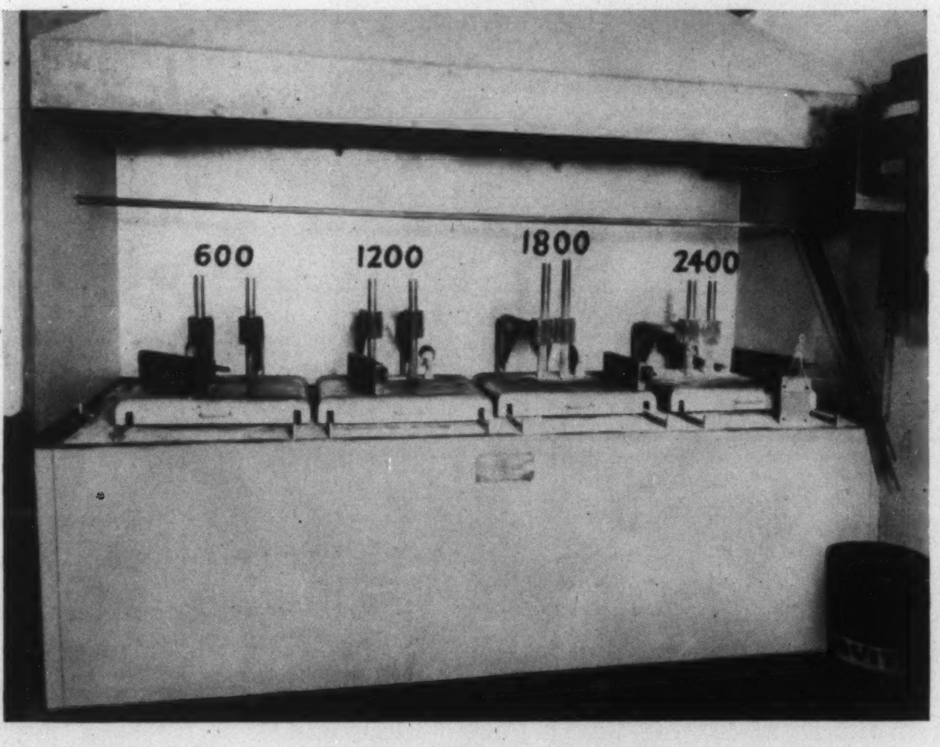

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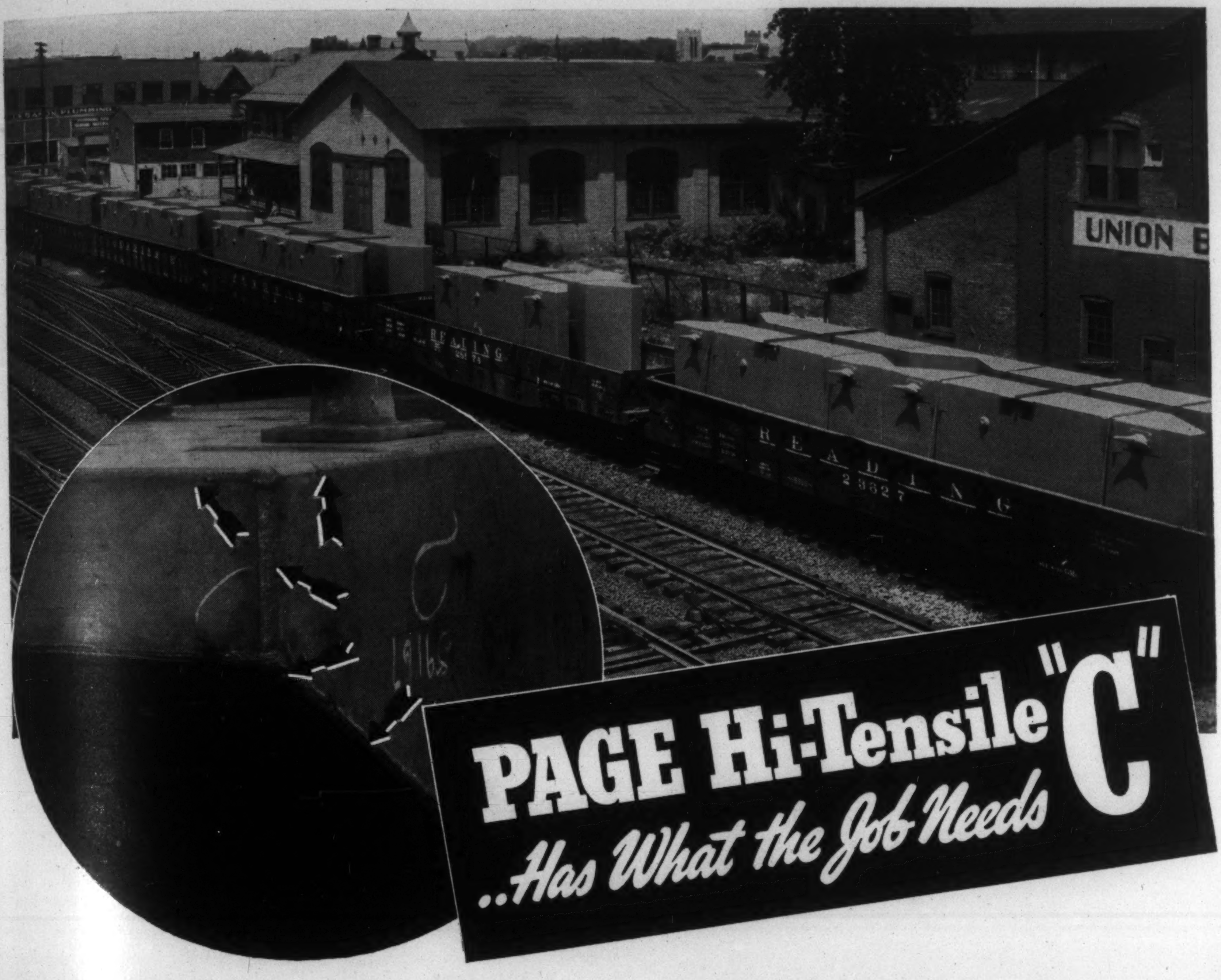

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Sintering Iron Powder

A Composite

Information on the separate effects of time, temperature and pressure on the ultimate properties of sintered metal compacts is being assiduously compiled by various sources. These are not the only controlling variables, of course, but in the present state of the art any reliable data that can possibly be correlated with specific operating conditions for various metals is decidedly welcome. Two recent studies of the effects of time, temperature and pressure on sintered iron compacts—their density in one case and their tensile strength in the other—are an interesting step forward.

Using iron powders all —200 mesh with about 50% —325 mesh, F. C. KELLEY of Gen. Electric Co. ("Effect of Time, Temperature and Pressure on the Density of Sintered Metal Powders," presented at the Feb. 1940 meeting of the A.I.M.E. and abstracted in *Iron Age*, Vol. 145, Feb. 22, 1940, pp. 36-37) studied the effects of those three variables on the density of metal powder compacts, particularly iron compacts. When their individual effects were not being studied, the variables were held at these values: pressure, 30 tons/in.^{2}; sintering temperature, 2600-2640° F.; sintering time, 32 hrs.

Varying the pressure from 10 to 70 tons/in.^{2} showed it to have only a slight effect on final density, with pressures of 30-60 tons/in.^{2} giving the highest densities. Temperature is the most important factor in bringing about the maximum amount of sintering [as measured by density]. Critical temperature for sintering iron lies between 2460° and 2550° F., in which range the greatest increase in density occurs. Time is of less, but still considerable, importance. Pure powdered iron, when pressed at 30 tons/in.^{2}, must be sintered at 2600°-2640° F. for about 64 hrs. to obtain the theoretical density of 7.86.

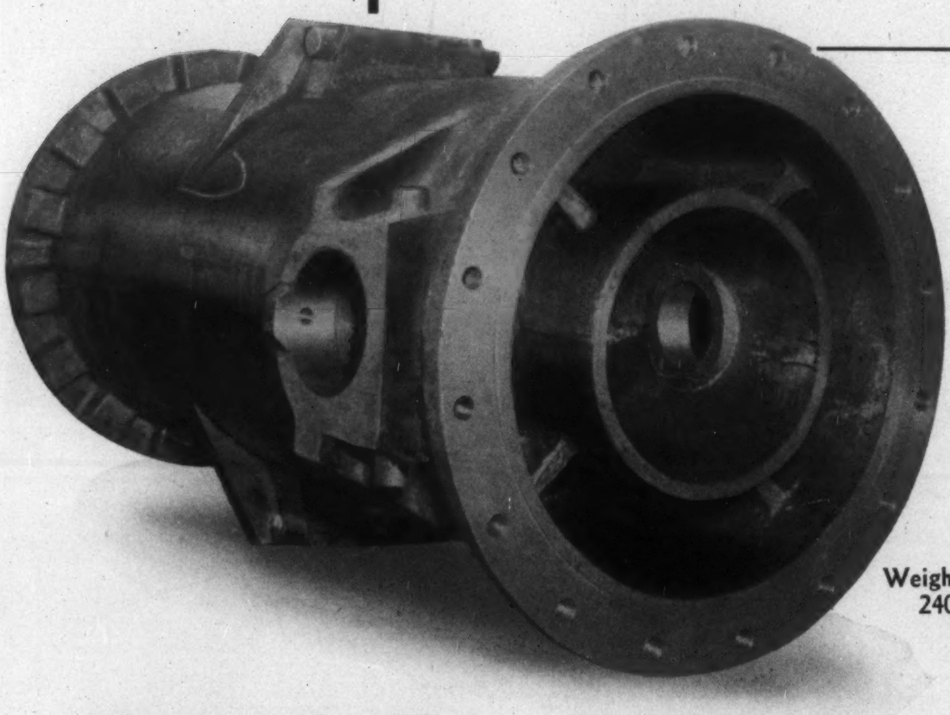
The effects of time, temperature and pressure on *tensile strength* appear to be quite different, according to W. EILENDER & R. SCHWALBE ("Einfluss von Sinterzeit, -temperatur und Pressdruck auf die Festigkeitseigenschaften von Sintereisen," *Arch. Eisenhüttenw.*, Vol. 13, Dec. 1939, pp. 267-272). Using pure iron powder of about 0.5 mm. mesh [approximately 50 mesh, much coarser than Kelley's], the strength was found to increase steadily with increase in pressing pressure up to the maximum test pressure of about 70 tons/in.^{2}

A sintering temperature of about 1500° F. gave a tensile strength of about 28,000 lbs./in.^{2}, and this value was only slightly higher at 2200° F. In-between, with a temperature of 1750° F., there was a slight falling off in strength and ductility, which was attributed to grain-coarsening. Ductility was higher with higher sintering temperatures, reaching a value of 18% elongation in 2 in. and 12% reduction of area, after sintering at 2200° F. Strength reached a maximum after a sintering time of 2 hrs., but the elongation kept increasing with sintering time up to the maximum time used of 8 hrs.

[This all proves what a lovely, simple thing powder metallurgy is not. On their face values these two sets of results would seem to indicate that tensile strengths of iron compacts bear little relation to their densities. Kelley finds pressure to have only a slight effect on density, while the Germans find it to have a strong effect on tensile properties. Sintering temperature has a potent effect on density but not so potent on tensile strength. And time, up to 64 hrs. sintering, steadily improves density, while in the case of tensile strength time just marches on without much effect after 2 hrs.

But deeper examination shows several basic differences in the test materials or conditions that may explain these divergences. There was a great difference in the particle size used in the two investigations, a fact that might account for the different pressure effects. Then, too, Kelley found sintering temperature to have its greatest effect above 2460° F., whereas the highest temperature studied by the Germans was 2200° F. And it's too bad the latter authors didn't extend their sintering times beyond 8 hrs., especially when one of the properties they were studying (elongation) was still increasing after that time.—F.P.P.] X (2a)

Chrome-Nickel Casting
For a Roasting Furnace



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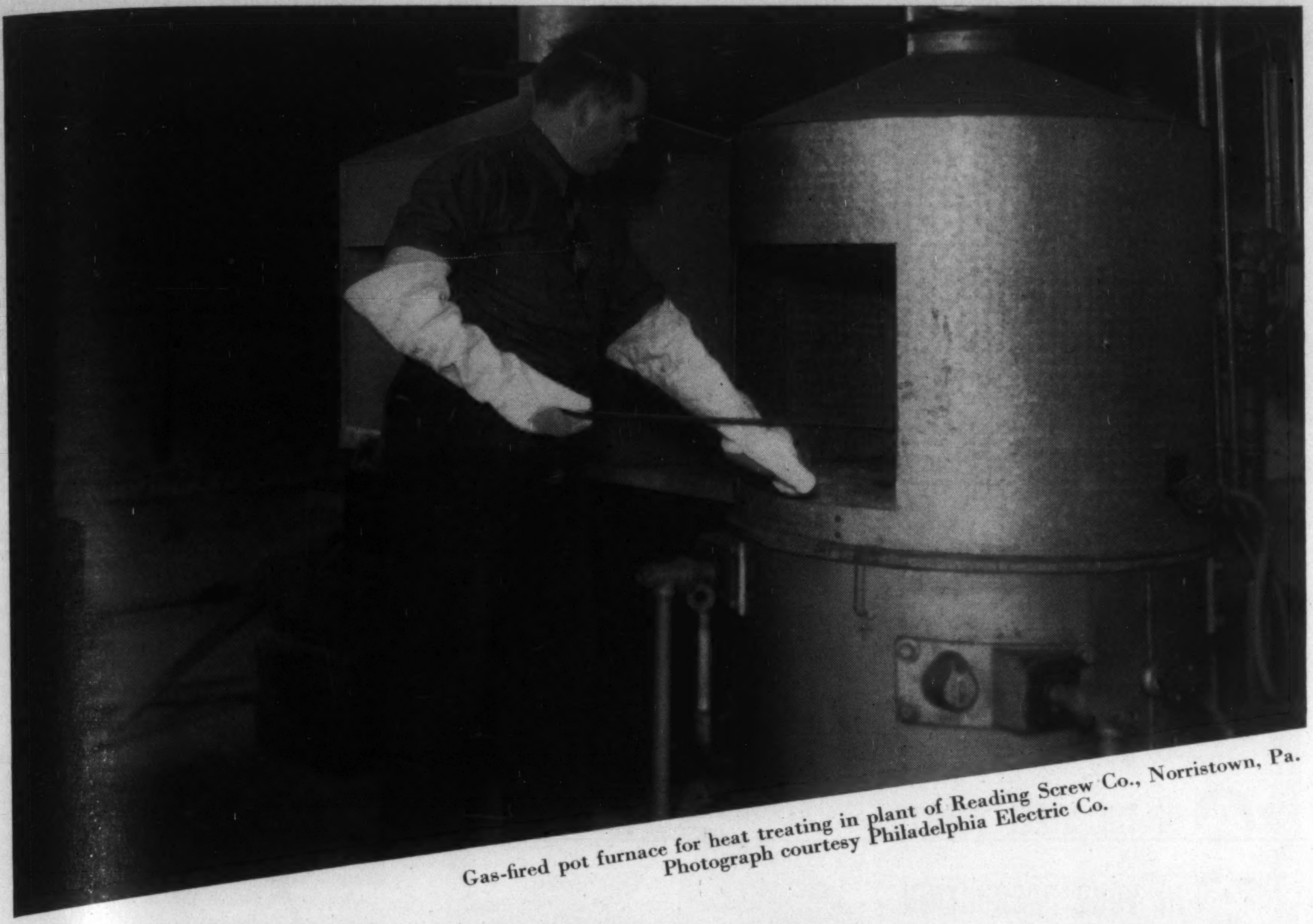
Welding Pipe and Fittings

"EXTENSION OF FUSION WELDING IN SPECIAL PIPE AND PIPE FITTING APPLICATIONS." E. HALL TAYLOR (Taylor Forge & Pipe Works) *Welding J., N. Y.*, Vol. 19, Feb. 1940, pp. 142-145. Descriptive.

Novel advances have been successfully carried into new ground recently in the fabrication of a high pressure fusion-welded penstock for a Pike's Peak installation. The maximum static head on this line is 2160 ft. which under surge conditions is equivalent to 1315 lbs./in.^{2}

Because of the special nature of the joints for this line, it was necessary to forge upset the ends of each penstock pipe section, thus subjecting the electric fusion-welded seam to extremely severe deformation. So far as



Gas-fired pot furnace for heat treating in plant of Reading Screw Co., Norristown, Pa.
Photograph courtesy Philadelphia Electric Co.

Low Cost Hardening of intricate steel parts ... with GAS

Lead, salt or cyanide pot furnaces, *gas-fired*, provide a most economical means of uniformly hardening small or intricate steel parts, according to the experience of the Reading Screw Company, Norristown, Pa.

The illustration shows the operator inserting a basket of screws to be hardened in a cyanide bath. Temperature is automatically controlled and the charge is rapidly and uniformly heated to the desired temperature and then quenched. The screws are used for metal fastening in the manufacture of automobiles, refrigerators and metal furniture.

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is known, this is the first time such drastic forging procedure has been successfully attempted on fusion-welded pipe, particularly for critical service under impact stress conditions. In forging the end of a pipe to increased thickness, it is important to have a uniform structure so that no irregularities occur in the upsetting operation, that is, no buckling of metal that might form a cold shut or other forging defect. Proper heating, shape of die and amount of upset per forging stroke must be controlled to get a good upset.

The pipe was made from 60,000-lb. minimum tensile strength steel plate. The plate was rolled to tubular form and the longitudinal seam fusion-welded. The weld was made by the Unionmelt process in a single pass against a backing-up bead. The 1⅛-in. thick pipe was welded with 1400 amp. at the rate of 6½ in./per min. The ½-in. pipe was welded with 1400 amp. at the rate of 17 in./min.

Since the weld metal was subjected to the same severe upset forging operation as the adjacent parent metal, an excellent opportunity was presented for comparing the effect of the forging operation on each type of metal and also to study the effect of forging weld metal in great quantities, since over 500 ends were thus forged. The visual impression of the forging operation was a favorable one. The weld metal forged as easily as the parent metal and after the completed operation, the weld metal was visually indistinguishable from the parent metal and at least equal to it on the basis of mechanical tests.

An extension of fusion welding in the field of special pipe fitting application is the growing practice of combining several standard fittings by welding, to form a special pipe fitting. The number of combinations made available by combining steel welding fittings and pipe, in view of the variation in sizes available by using eccentric and concentric reducers, is truly astronomical. Piping fabricators are using this new tool to great advantage. The accuracy of dimensions of standard fittings, plus the skill of the fabricator, enables the fabricator to deliver complete piping units that require only the end connections to be made to complete an installation. CEJ (2a)

"Machining Steel with Carbide Tools"—A Correction

In our February issue, page MA 85, we published under the above-quoted heading a digest of an article by P. M. McKenna of McKenna Metals Co. Mr. McKenna has since pointed out that the statement in the digest that "tools made from tungsten-titanium carbide ($WTiC_2$) are very suitable for machining materials that produce a crumbly chip, like cast iron and brass" is exactly opposite to the sense of his original article as it appeared in *Modern Machine Shop*.

What the author actually said in his article was that *tungsten carbide* compositions are suitable for machining materials like cast iron and bronze having a crumbly chip, but that for the machining of steel the new Kennametal compositions containing $WTiC_2$ were necessary.

Mr. McKenna stresses that tungsten-titanium carbide is not recommended for machining cast iron and other materials of similar tensile strength that cut with a crumbly chip, but instead finds important application for machining tough, hard and strong steels, which form coiled chips.

Our apologies to this author for so completely reversing his original meaning. FPP (2a)

Flame Hardening Iron Castings

A Composite

Smart use is being increasingly made of the circumstance that the usual cast iron matrix is as amenable to flame hardening as is steel. There are many applications of iron castings in large machinery that would approach perfection (and incidentally be made safer against competition from other metal-forms) through the use of this technique on certain heavily-taxed surface areas.

Among such hitherto vulnerable regions have been the way-surfaces of cast iron lathe beds, normally subject to severe wear. The flame hardening of such surfaces to increase their wear resistance is described by F. C. Dull of Monarch Machine Tool Co. ("Flame Hardening of Way Surfaces of Machine Tools," *Welding J., N. Y.*, Vol. 19, Jan. 1940, pp. 39-41). A composition of Monarch lathe beds is given as 3.20-2.80% total C; 0.75-1.70 combined C; 2:00-1.70 Si; 1.00-0.70 Mn; 1.50-1.00 Ni; 0.10-1.00 P; 0.10-1.00 S; O.25-1.00 Cr or Mo. This iron has a fully pearlitic matrix, and can be fully hardened from a temperature of about 1320° F.

For all beds in lathe sizes from 12 in. up a minimum depth of hardness of ⅛ in. is standard. By localizing the heat at the burners and by means of a circulating water bath, and quenching with the proper water pressure, distortion is held to a minimum. The average distortion in a bed of comparatively small structure, and as long as 8½ ft., hardened to a depth of from ⅛ minimum to ¼ in. maximum, is approximately 0.008 in. This distortion is, of course, eliminated in the grinding, and the final tolerance is 0.0005 in. or less in

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the overall-length. In 2 lathes under test, after 15 million passes the unhardened bed is badly scored, while the hardened bed shows no wear whatsoever.

The equipment and technique employed in flame hardening a widely-used heavy-duty cast iron is discussed by F. H. BICKFORD of Farrel-Birmingham Co. ("Flame Hardening of Meehanite," *Iron Age*, Vol. 145, Jan. 11, 1940, pp. 19-21; Jan. 18, 1940, pp. 31-34). Equipment may vary from simple portable hand blow-pipe set and pan of water for spot hardening of small parts to a complete acetylene generating system, central oxygen manifold and a special machine for moving torches and water-quenching device over the work. A suitable quenching device may be made by drilling small holes in a piece of pipe; quenching by a stream of water is more efficient than total immersion.

In progressive hardening, the width of the hardened path depends on the width of the burner and may be as narrow as 1/4 in. or less. Precautions must be taken when passing over edges or holes because the heating rate is increased and heat dissipation into the body of the part is less rapid, resulting in dangerously high temperature. At such places either speeds should be controlled or shields inserted. Heating is so rapid that traversing speeds of 6-8 in./min. are commonly used. Attempts to flame harden rough casting surfaces have not been successful, probably because of the oxide coating, which acts as an insulator against heat. The surface should therefore be machined prior to flame hardening.

The hardening of cylindrical castings can be done by the spiral progressive method. The lathe is well suited for hardening small rounds by the spinning method, which differs from the progressive method in that the entire treated surface is heated before any quench is applied. A serviceable hardening machine may be made by conversion of a small horizontal boring mill or milling machine. Standard flame cutting equipment is well suited for flame hardening because the range of speeds encountered in hardening corresponds to that used in cutting.

The vertical combination method for hardening cylindrical objects has been patented and extensively developed. Rolls treated by this method are supported in vertical position and rotated while the torch and quench assembly entirely surrounding the roll in the horizontal plane is passed upward over it. Thus, the entire roll is hardened in a single pass. A similar process is also used in hardening cylindrical interiors, except that the flames and quench are directed radially outward.

In flame hardening Meehanite, the zone of maximum hardness extends from just below the surface to about 1/2-3/4 of the total depth of case. This zone consists of martensite with a hardness of 550 Brinell, and its transition to the underlying base metal is gradual, martensite blending into sorbite and finally to pearlitic base metal, with a hardness of about 240 Brinell. The greatest hardness is obtained by setting the flames close to the surface.

The distortion factor in flame-hardened castings is usually small, because only a small depth is treated while the core remains relatively cool. If stresses are present before hardening, they will tend to relieve themselves through deformation when heat is applied. Therefore, stress relieving of castings prior to hardening is suggested in order to reduce distortion. Checking seldom occurs except where the surface becomes overheated. The wear resistance of flame-hardened Meehanite is said to be sometimes superior to that of flame-hardened steel.

X (2a)

2b. Non-Ferrous

Flame-Cutting Non-Ferrous Metals

"FLAME CUTTING NON-FERROUS METALS AND NON-METALLIC MATERIALS AND OXIDATION OF METALS AT ELEVATED TEMPERATURES. A REVIEW OF THE LITERATURE TO JULY 1, 1938." W. SPRARAGEN & G. E. CLAUSSEN (Welding Research Comm.) *Welding J., N. Y.*, Vol. 19, Feb. 1940, pp. 51-s—60-s. 86 references.

The methods now employed for flame-cutting non-ferrous materials do not depend on oxidation for their success, and thus differ fundamentally from the process of oxygen-cutting used for steel. The carbon arc process is a useful method for cutting copper alloys, which are not amenable to cutting with the oxygen torch.

In 1919 the flux-cutting or sandwich method was developed in which brass and bronze plates to be cut are sandwiched between waster plates of steel. The acetylene torch may be employed freely by competent operators for cutting risers on brass and bronze castings. In large foundries the acetylene torch is used for cutting bronze sheets and scrap castings to charging size. A patented torch for cutting lead by melting consists of a central nozzle for the flame, which may be oxyacetylene, oxyhydrogen or oxy-city gas, with a surrounding jet for delivering cool gas to the sides of the cut. Air or nitrogen sucked in by an oxygen injector is ordinarily used for cooling. Zinc is difficult to cut. A writer in Scotland cut nickel sheets with a coal-gas torch and an auxiliary torch supplying nitrogen, presumably to the edges.

The failure of the oxygen-cutting process to cut anything except iron, high-iron alloys and possibly manganese and one or two other uncommon metals is not easily explained. It is true that torches can sever practically any non-ferrous metal by melting, but oxidation, if it is a factor at all, is a minor one. Four main reasons have been advanced for the failure of the oxygen-cutting process when applied to the majority of metals: (1) The metal has a low or negative heat of oxidation. (2) Intergranular penetration of the oxide into the metal does not occur. (3) The oxide melts at a higher point than does the metal. (4) The ignition temperature is higher than the melting point of the metal.

When plain carbon steel (0.15% C) is heated in oxygen above 2300° F., the reaction proceeds with such rapidity that the heat of oxidation is not conducted from the seat of reaction by the flowing gases or by the surroundings with sufficient rapidity to prevent a rise in temperature of the steel. Therefore, the specimen is completely oxidized in a very short time. In air, carbon dioxide, and steam, the same phenomenon is observed above 2500° F. These temperatures are in the vicinity of the melting point of the scale, and several investigators have confirmed the fact that the oxidation rate suddenly increases when the scale melts.

The ignition temperature depends upon the degree of subdivision and for iron ranges from 5° F. for pyrophoric powder, through 1650° F. for thin wire, to above 2300° F. for large masses. The lower ignition temperature of material of smaller cross section is taken advantage of by operators who, before commencing cuts on large cylindrical shafts, raise a small burr at the starting point by means of a chisel. The ignition of the burr supplies liquid oxide for propagating the ignition to the massive steel. The liquid oxide may provide a more intimate and concentrated

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supply of oxygen to the steel than the cutting jet, which, besides, is quite cool. In this way the thermal capacity of the cold shaft is overcome.

It seems probable that any metal with appreciable heat of oxidation can be ignited, if it is sufficiently finely divided. The effect of alloying elements on the oxygen-cutting of metals can scarcely be evaluated in view of the uncertainty about the essential characteristics of the cutting of unalloyed metals. If the alloying element has a higher heat of oxidation than the metal, it should favor ignition. Whether it also favors oxygen-cutting cannot be predicted.

For example, aluminum and silicon have higher heats of oxidation than iron, and their oxides lower the melting point of iron oxide. Yet both elements are unfavorable to oxygen cutting. Nickel, which has a low heat of oxidation, appears to act as a neutral diluent in iron, gradually increasing the difficulty of flame cutting by diluting the scale with metallic nickel. Manganese, itself susceptible to oxygen cutting, seems to have little effect on the oxygen cutting of iron. CEJ (2b)

Thiosulphate Plating Baths

"Single Metal Deposition of Copper, Cadmium, Zinc and Nickel from Thiosulfate Solutions". D. C. Gernes (Tenn. Valley Authority), G. A. Lorenz (Shell Petroleum Corp.) & G. H. Montillon (Univ. Minnesota) *Trans. Electrochem. Soc.*, Vol. 77, 1940; Preprint No. 1, 27 pp. Original research.

A typical bath for the electrodeposition of copper contained 500 g./l. sodium thiosulphate ($Na_2S_2O_3.5H_2O$) and 40 g./l. cuprous chloride. A current density of 1 amp./dm.^{2} at 25° C. was used with mechanical agitation. By potential measurements, the copper in the bath was shown to exist as a complex ion. The maximum current density at which the bath could be operated at room temperature, without agitation, was about 0.5 amp./dm.^{2} Above this current density the deposits became dark from formation of sulphides. The current density could be increased to 2 amp./dm.^{2} by raising the temperature or by agitating the bath.

The cathode current efficiency was close to 100%. The freshly prepared bath was almost colorless, and stable at room temperature if the weight ratio of thiosulphate to cuprous chloride was about 10. (The cuprous chloride should not contain more than 0.25% of cupric chloride.) Decomposition occurred about 50° C. with formation of a black precipitate. Very little, if any, deposition of copper on steel by immersion occurred in the bath of the above composition, but deposition occurred in baths containing less thiosulphate or more copper. The electro-deposits were not very adherent. The addition of 10 g./l. of sodium acid sulphate ($NaHSO_3$) to the bath produced more adherent deposits.

Cadmium was deposited from a bath containing 40 g./l. cadmium sulphate ($3CdSO_4.8H_2O$), 250 g./l. sodium thiosulphate and 40 g./l. ammonium chloride. With agitation, a current density of 1.5 amp./dm.^{2} was used at room temperature. The deposits contained 95% cadmium. They were adherent and could be buffed to a good polish. The initial cathode current efficiency was about 90%, but it decreased as the bath was used.

Zinc was deposited from a bath containing 120 g./l. zinc sulphate ($ZnSO_4.7H_2O$), 200-400 g./l. sodium thiosulphate, and 25-50 g./l. ammonium chloride. The current density was 1-2 amp./dm.^{2} with agitation. The deposit was smooth, adherent and contained no sulphur. The bath formed zinc sulphide when freshly prepared and operated at too high a current density or at elevated temperatures.

Nickel was deposited from a bath containing 200 g./l. sodium thiosulphate, 48 g./l. nickel chloride ($NiCl_2.6H_2O$) and 25-50 g./l ammonium chloride. The deposits contained 22-70% sulphur. They ranged from non-adherent, brittle coatings, yellow or black in color, to bright, adherent nickel-white deposits. The latter contained about 22% nickel and were obtained at 1 amp./-dm.^{2} from an agitated bath. Several mechanisms were proposed for the formation of nickel sulphides in the deposit by the reduction of thiosulphate ion to sulphide and sulphite ion. AB (2b)

Lead Cable Sheathing

"A New Technique for Lead Cable Sheathing." B. B. Reinitz & R. J. Wiseman (Okonite Co.) *Elec. Engr.*, Vol. 59, Mar. 1940, pp. 165-178. Research.

Since the early days of cable manufacture, much improvement has been made in the interior of lead covered cable for the transmission of power at higher voltages by improving the insulating materials such as paper and oil, and by better drying, degasifying and impregnation methods. Defects in the outer lead sheath, however, have been an ever increasing source of cable failures and today are the chief source of difficulty, as reported by the Association of Edison Illuminating Companies and the Edison Electric Institute.

Recent attempts to improve the foundry practice have resulted in the vacuum press, in which the lead-press cylinder is filled with molten metal under conditions in which most of the air is eliminated; hy-

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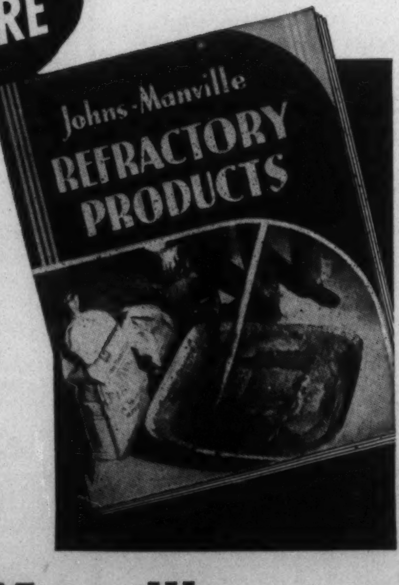

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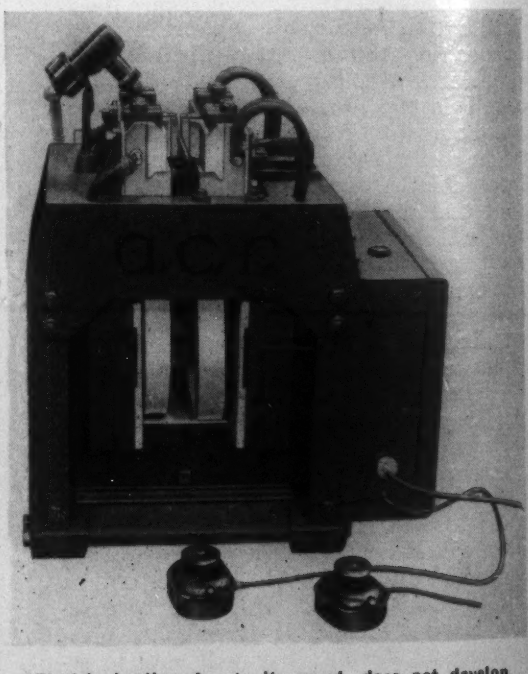

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drogen flame, where the metal is poured in the presence of burning hydrogen to prevent surface oxidation of the molten lead; electric arc or oxyacetylene flame which melts the oxidized surface of the residual charge; high density inert gas to maintain a nonoxidizing gas blanket over the molten lead; and continuous extrusion machines. None of the above methods has resulted in a lead sheath free from laminations.

A careful study of lead-pipe manufacture indicated two distinct problems: (1) The method of filling the lead press cylinder, and (2) the chemical stability of the lead. The solution of these two problems resulted in a satisfactory sheath. Studies of conditions in the lead press cylinder showed that the new charge of lead splashing upon the old charge picked up occluded gas from the air. In addition the union of the new charge with the old was incomplete because the old charge is at a lower temperature (250° F. compared with 700° F. for the new charge.) This lack of union of the two charges reveals itself as laminations in the microstructure of the extruded sheath.

A union of the two charges has recently been obtained by the use of the Hill standpipe method, in which the molten lead is introduced by filling from the bottom. This eliminates splashing of the lead and gas occlusion, and enables the new hot lead to rise to the surface of the old charge with uniform mixing of the two charges. This method of melting has prevented laminations in the extruded cable sheath.

The next problem to study was the elimination of oxides and other deleterious impurities which remained as inclusions. After several years of study, it has been found that the chemical stabilization of lead and its alloys could be reached by the addition of small amounts of metallic sodium (added in the form of a sodium-lead master alloy) in the amount of 0.005 to 0.05% by weight of the amount of lead being treated. At a bath temperature of 850°-900° F. the sodium deoxidizes the lead and decomposes the sulphides which may be present. The small amount of residual sodium, about 0.001%, stabilizes the charge so that it does not dross on further heating but remains silvery in appearance. The results have been to eliminate inclusions in the extruded sheath.

Tests to show the effect of the new alloy on corrosion resistance of the sheath were conducted by submitting both the standard lead sheath and the lead sheath containing sodium to live steam at 220° F. for 100 hrs. The treated lead had a white deposit of lead hydrate, $Pb(OH)_2$, which could be readily rubbed off. The untreated lead had a brownish white deposit on the surface which was hydrated lead monoxide, $PbO.Pb(OH)_2$. This deposit was embedded in the surface and could be removed only by a sharp tool. Furthermore, boiling both the treated and untreated lead for long periods of time showed a higher alkalinity in the water of the untreated lead than in the treated lead. These tests would seem to indicate improved corrosion resistance for the sodium-treated lead.

Creep tests carried out at 60° F. over a period of 2500 hrs. on treated and untreated lead samples showed practically no difference when stressed at 500 lbs./in.^{2} but at 850 lbs./in.^{2} the untreated lead stretched faster than the treated lead.

Time-pressure tests were conducted on full-charge lengths of sheath with 2.80 in. outside dia. and 0.141 in. wall with sealed ends and an internal pressure of 90 lbs./in.^{2} of air (805 lbs./in.^{2} circumferential stress). This stress was applied for 10 days and then the pressure increased 10 lbs./in.^{2} internal pressure every 5 days until rupture occurred. Rupture in the untreated sheath had a straight knife edge fracture but in the treated sheath the edge was wedge shaped and failure occurred at higher pressures. The above tests have resulted in a cable sheath of stabilized metal free of oxides, sulphides and occluded gases, with a complete welding of the charges in the lead-press.

In the discussion of this paper, L. Zickrick of General Electric pointed out that purity of the lead was usually associated with lower tensile properties, larger grain size and lower fatigue resistance. I. T. Faucett of General Cable Corp. suggested that present methods of extruding lead sheath were better than those claimed by the authors and that laminations and poor welding were no longer inherent in the finished product. He claimed the vacuum press method was superior to the Hill standpipe method of extrusion.

D. M. Simmons of General Cable Corp. stated that short time burst tests at relatively high internal stresses resulted in wedge shaped fractures due to gradual necking down of the lead. On the other hand, for long time tests at much lower stresses, it can be stated generally that when either die welds or flow lines are involved, the sheath fails by fractures abruptly without necking down and the result is a knife edge. The exact character of failure is also influenced by temperature and unit stress in the material.

W. H. Bassett of Anaconda Wire and Cable Co. said that he had made many full charge bursting tests and believed that all samples break with a knife edge fracture when tested above 100 lbs. (1000 lbs./in.^{2} hoop stress) unless the sample is definitely defective.

FHC (2b)

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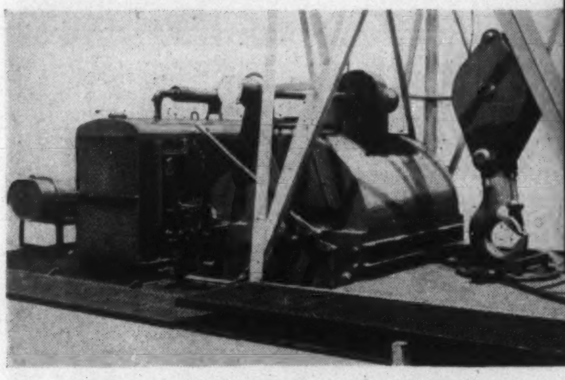

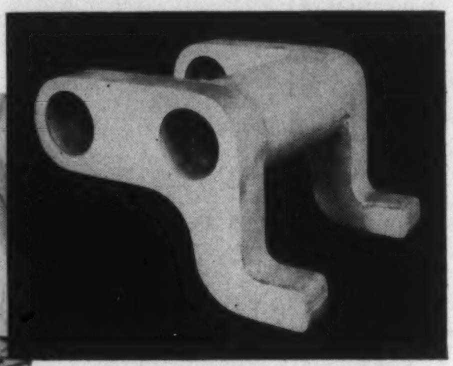

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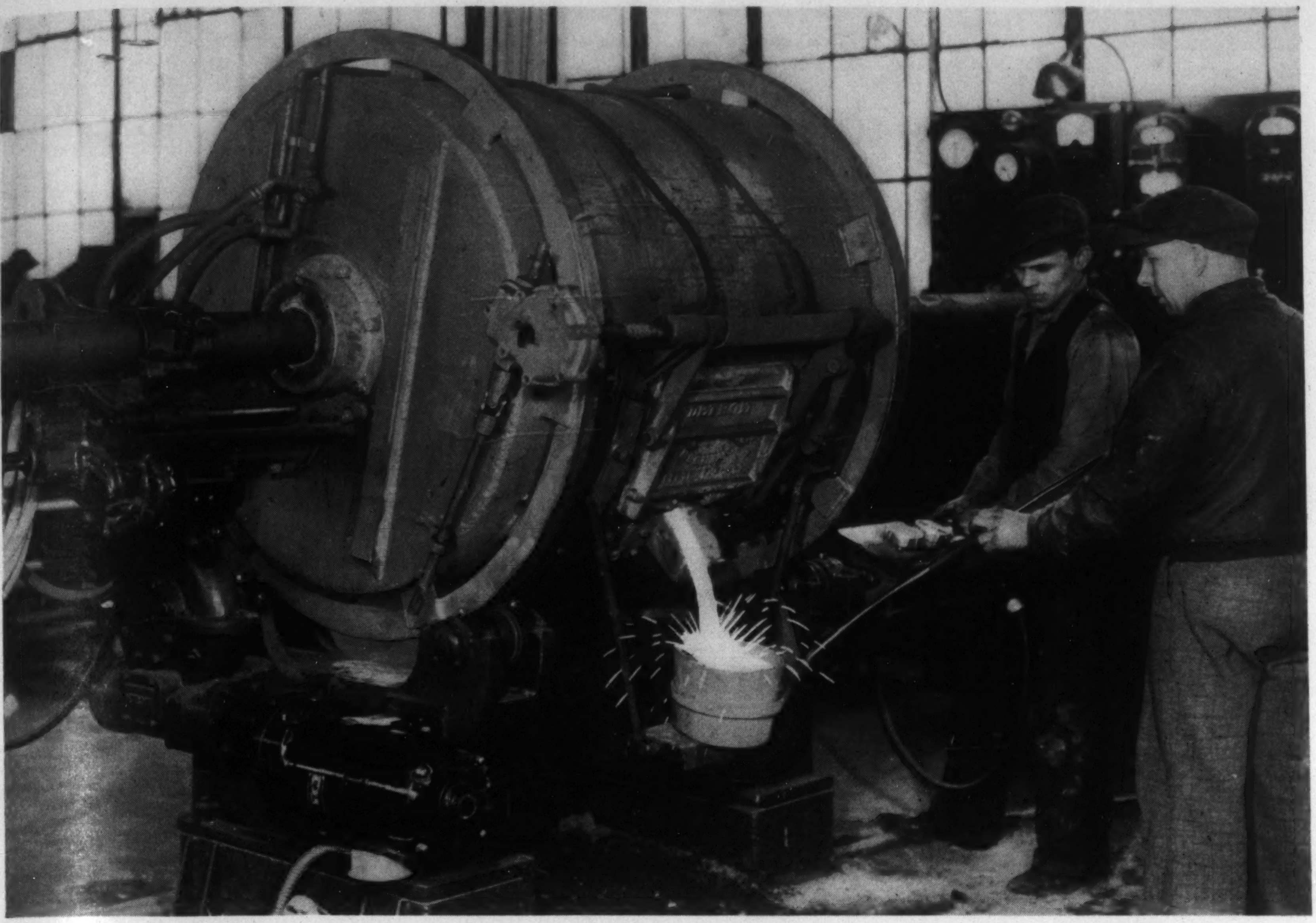

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METALS, ALLOYS, METAL FORMS
ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

Bearings and Lubrication

A Composite

The design of engines and moving mechanical structures of all types rests to a surprising extent on metallurgical engineering. Today's designer must be a pretty competent metallurgical engineer if he is to do an intelligent job of pairing off bearing surfaces, selecting bearings according to type, shape or structure, determining the best lubricant to avoid corrosion and still give efficient, quiet, minimum-metal-wear performance, and so on. Several recent articles on lubrication, wear and bearings discuss many phases of this general topic, and indicate the necessarily great dependence of the engine designer, in his day-to-day work, on metallurgical engineering.

Classification of types of metal-wear, wear-reducing properties of oils, corrosive attacks on bearings, and extreme-pressure lubricants are among the items of metallurgical interest discussed in a recently-issued pamphlet ("Evaluation of Petroleum Products," published by Am. Soc. Testing Materials, 64 pp., price 75 cents; abstracted by **LOUIS JORDAN** in *Mining & Met.*, Vol. 21, Mar. 1940, p. 158). "Wear" is classified as of 3 types: (1) abrasion due to foreign particles in the oil film, (2) mechanical wear due to metal contact between the bearing surfaces, and (3) corrosion of the bearing surfaces due to oxidation or chemical reaction by the products of combustion or by active compounds in the lubricant.

Studies on wear of cylinder wall and rings definitely show that structure of metal and ring design, dust in the atmosphere, and engine speed have a greater effect than oil variations. A low jacket temperature (120° F.) *increases* cylinder wall and ring wear due to corrosion by water and combustion gases. Laboratory tests showing that some oils corrode copper-lead and cadmium-silver bearings at elevated temperatures have yet to be correlated with engine tests.

Extreme-pressure lubricants (such as the lead soap - active sulphur petroleum greases) owe their load-carrying capacity to their exceptional ability to maintain a film and to their function of bringing about a chemical reaction on the bearing surface itself.

¶ Cylinder-bore and piston-ring wear have been aggravated in recent years by heavier service, and stable lubricating oils with wear-inhibiting properties have been sought, to obviate expensive changes in bore materials. Nitriding of bores has been successful, but is considered expensive, and other methods of reducing wear are being investigated. Castor oil seems to have inhibited wear, seizing, etc. in racing aircraft engines, in comparison with normal mineral oils, but poses operating problems of its own. The effect on wear of oils that have been drastically solvent refined is still a controversial topic.

Corrosion of copper-lead bearings by straight or compounded mineral oils is not now an important problem, but may become so with future changes in oils, engine operating conditions or bearing materials. Cadmium-silver or cadmium-nickel bearings are in use in low- or medium-power commercial engines in this country, but no data on bearing corrosion are at hand. In Europe, new aluminum-base materials are coming into use and must be considered in the development and use of new oil types or blends.

Lubrication of bearing surfaces of heavy machinery, such as that used in steel manufacture, a different sort of problem, is discussed by C. C. **PECU** of Bethlehem Steel Co. ("Progress of Lubrication in the Steel Industry," *Iron & Steel Engr.*, Vol. 17, Jan. 1940, pp. 45-51). Again, there has been a close tie-up between lubrication problems and the nature and design of bearings. For example, in roll necks, suet was a good lubricant for the early open, solid bronze bearings; hardwood bearings require only water for lubrication; synthetic resin bearings operate with water at high speeds, with grease at low; roller bearing makers recommend an extreme-pressure lubricant; the flood-lubricated sleeve type bearings rapidly superseding roller bearings on back-up rolls rely on the high-viscosity of a straight mineral oil, aided by the neck rotation in the bearing, to produce an unbroken film of oil.

A still different type of bearing and lubricant service is found in Diesel engines, new lubricants for which are described by G. L. **NEELY** of Standard Oil Co. of Calif. ("Recent Development in Diesel Lubricating Oils," *S.A.E. Journal*, Vol. 45, Nov. 1939, Trans. pp. 485-500). Investigation was made of a new compounded oil by small-scale and engine-tests in the laboratory and by field tests, using various types of bearings. Corrosion and wear tests were included. The new oil, a specially-treated, napthenic-base mineral oil, is as non-corrosive to all types of bearings (corrosion tests included some on copper-lead and cadmium-silver at 300° F.) as the most non-corrosive mineral oil. The new oil reduces wear at both high and low temperatures, according to engine and laboratory tests with hard steel/hard steel and aluminum alloy/cast-iron cylinder/piston-ring combinations.

Automotive crankshaft bearing problems have been attacked chiefly from the journal standpoint, with crankshafts being made of a variety of materials or with a variety of treatments. C. G. **WILLIAMS** & H. **LUDICKE** ("Wear of Crankshafts with 'Lead-Bronze' Bearings," *S.A.E. Journal*, Vol. 46, Mar. 1940, pp. 93-99) investigated the relative wearing properties of various crankshaft materials when running against a typical copper-lead bearing at 212° F. A new bearing and crank-pin were used for each test and were run-in carefully for 8-10 hrs. The testing machine was virtually a dummy engine, in which the bearing under test was inserted in the big end of the connecting-rod. Each bearing and crank-pin were run for a total of about 100 hrs.; the machine was stopped and dismantled every 20 hrs. for measurement of wear. Mineral oil with viscosity of 82.4 saybolt sec. at 212° F. at an initial pressure of 50 lbs./in.^{2} and a flow of 7.2 pints/hr. was used.

The crankshaft materials and treatments studied were as follows:

(a) Forged steel with 1.3% Ni, 0.6 Cr; heat treated and ground; Vickers hardness 260
(b) Forged steel, 0.5% C; untreated, ground; Vickers 164
(c) Same as "b," except heat treated (and ground) to Vickers 255
(d) Forged steel, 0.80% Mn, 0.74 Ni; untreated, ground; Vickers 208
(e) Forged steel, 2.08% Ni, 1.16 Cr, 0.35 Mo; untreated, ground; Vickers 373
(f) Same as "e," except heat treated to Vickers 326 and ground. [Note the lower hardness. The authors say they followed the steel manufacturer's heat treating recommendation.]
(g) Cast steel, 1.2% C, 1.76 Si, 0.55 Cr, 2.58 Cu; untreated; Vickers 330
(h) Cast steel, 0.3% C, 2.47 Ni, 0.42 Cr, 0.35 Mo; untreated; Vickers 276
(i) cast iron, 2.94% C, 1.3 Si, 0.33 Mo, 1.2 Cu; Vickers 270
(j) Chromium-plated and ground to 0.0025 in. thick plate; Vickers 876
(k) Chromium-plated to 0.001 in.; Vickers 498
(l) Chromium-plated to 0.0022 in.; Vickers 820
(m) Carburized; Vickers 886
(n) Nitrided; Vickers 1150
(o) Specially-surface-hardened; Vickers 746 ("proprietary process" in which outer surface is said to be converted into a ferrous alloy containing aluminum, silicon and chromium)

Crank-pin "c" outwore "b" 2 to 1 and reduced bearing wear 80%—indicating the advantages of heat treating this plain carbon steel. As might be expected from their hardnesses, crank-pin "e" outwore "f", but the ratio—8 to 1—is surprising. The rate of wear of "e" was very low, only 1/4 that of "a". Steels "b" and "d" wore very rapidly. Bearing wear with pearlitic steel crankshafts was very much higher than that with sorbitic steels.

Among the cast materials "g" gave the best performance with regard to both bearing and crank-pin wear, and gave better performance than any of the forged materials. Cast material "h", similar in com-

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position to forged steels "e" and "f", outperformed "f" but not "e".

With the plated materials, crank-pin wear was twice as great with the thick deposit on "k" as with the thinner but harder deposits on "j" and "l". Comparison with results for "a", however, indicates little advantage in chromium plating for crank-pins.

Crank-pin and bearing wear were very low with nitrided crank-pin "n". Pin wear for the carburized steel "m" was of the same order, but bearing wear was at least 3 times heavier than with "n". The "proprietary-processed" "o" gave low crank-pin and bearing wear. Case-hardening is a satisfactory means of reducing crank-pin wear with copper-lead bearings. Thus, the wear of "a" was 3 times greater than it was with either of the case-hardened pins "m", "n" or "o". For the case-hardened steels (in contradistinction to the softer surfaces) bearing wear occurred more rapidly than pin wear, due chiefly to high initial bearing-wear. Better surface of pins might have lowered this initial bearing wear.

Crankshaft bearings of the light metal type previously mentioned are appraised by Karl Künzel ("Erfahrungen mit Leichmetall-Pleuellagern bei Serienmassiger Verwendung in Schleppermotoren," *Automobiltech. Z.*, Vol. 42, Dec. 1939, pp. 645-647). Various commercial light alloy bearings of different manufacturers were service-tested in a standard tractor engine. The emergency running properties were determined by running for 6 hrs. and then completely stopping the oil supply.

The character of the seizing was different for different bearings. Under the same conditions, higher running time was obtained with babbitt than with light metal bearings. The best of the latter were put into actual service and without exception stood up well over a period of several years. Clearances should be 2.5 to 3 times those with babbitt or bronze bearings. Hardened shanks are preferable, and mechanical finishing of the bearing with a diamond tool was much more practical than the customary hand-scraping.

Another light metal bearing gaining wide acceptance is the Rolls-Royce aluminum-tin bearing, discussed among other things by E. W. Hives & F. L. Smith ("High-Output Aircraft Engines," *S.A.E. Journal*, Vol. 46, Mar. 1940, pp. 106-118). All Rolls-Royce cars are now fitted with aluminum-tin big-end bearings and a high-performance sport model has aluminum-tin main bearings. The material is being applied to aircraft engine big-end bearings with great promise.

For big-end bearings, the most satisfactory Al-base alloy contains 5.5-7.0% Sn, 1.4-1.7 Ni, 0.7-1.0 Mg and 0.6-0.9 Cu; for main bearings, 4.6-5.0% Sn, 1.6-2.0 Ni, 0.7-0.9 Mn, 0.4-0.8 Sb, 0.45-0.6 Si and 0.35-0.5 Mg. Shaft hardness of at least 600 Brinell is necessary to prevent seizure with aluminum-tin main bearings, although big-end bearings have been run successfully with shaft hardnesses as low as 320 Brinell. The hardness of the bearings themselves range from 42 to 100 Brinell at room temperature and 36 to 90 Brinell at 300° F., according to specific composition.

The frictional characteristics of the Rolls-Royce bearing were investigated by running several flat, circular disks of the alloy against a flat nickel-chromium steel plate under predetermined conditions of temperature, load, oil supply and speed, with the oil supply repeatedly interrupted until breakdown occurred. The aluminum-tin alloys withstood this test much better than a 70-30 copper-lead alloy.

The wear of aluminum alloy bearings is less than what was once considered normal for tin-base babbitts, says A. B. Willi of Federal Mogul Corp. ("How Materials Affect Plain Bearing Performance," *Machine Design*, Vol. 12, Mar. 1940, pp. 43-47) in a comprehensive review of bearings and bearing metals. He cites the use in England of aluminum bearings in Diesel engines for regular production. The necessity to use aluminum bearings in conjunction with a hardened shaft is echoed.

The design features of self-lubricating bearings made by powder metallurgy are illustrated in an article by G. Z. Griswold ("Powder Metallurgy Has Great Design Possibilities," *Machine Design*, Vol. 12, Jan. 1940, pp. 41-43, 83). Such bearings, which may contain 90% Cu, 10% Sn and a small amount of graphite, are porous and are impregnated with oil, which in operation oozes to the surface by capillary action. X (3)

Electroplates as Metal-Forms in Engineering Design

A Composite

A notable trend in engineering practice today is the increasing use for industrial purposes of electroplated surfaces or completely electro-formed parts. Once employed solely for appearance or surface protection, electroplating has now become a "fabricating" operation as well, and electroplates must be considered along with sand castings, die castings, powder compacts, welded, woven or punched assemblies, etc. when available metal-forms are being considered for some special application.

The preparation of molds and dies for a variety of purposes by electro-forming iron against a pattern to be reproduced was described recently in this magazine ("Electro-forming with Iron—the Ekko Process," Metals and Alloys, Vol. 10, Nov. 1939, p. MA 636). The heavy iron deposit so produced is 50% harder than cold rolled steel, has a Brinell hardness of 240, and when separated from the underlying pattern, provides a cavity or die insert that reproduces the shape and surface finish of the pattern in every detail.

The production of metal screen by electro-forming is another development that has opened up interesting design possibilities for electroplates ("Metal Screen Made by Electroplating," Metals and Alloys, Vol. 11, Feb. 1940, p. MA 60). The product is designed to serve purposes lying between those covered by perforated metals on the one hand and woven wire on the other, and offers the design engineer accuracy in hole diameters plus the smooth surface characteristic of plated metals. The screen ("Lektromesh") has been produced in copper, nickel and other metals, and commercially applied in fuel-system strainers, loudspeaker screens, screens for clock dials, etc.

Electrodeposition also offers a means of preparing excellent silver-lead alloys for bearings, according to C. L. Faust & B. Thomas ("Electrodeposition of Silver-Lead Alloys for Bearings," *Trans Electrochem. Soc.*, Vol. 75, 1939, pp. 185-199). The alloys contain 3-5% Pb, and the method is not subject to the difficulty of securing a good bond to the back that is present in the current methods of lining bearings by casting. Deposits several hundredths of an inch thick were plated and the bath was stable on continued operation. There was no visible structure or segregation of lead in the electrodeposited alloys.

Somewhat akin to bearing service is that to which large pistons and cylinders of Diesel engines are subjected. According to H. Van der Horst ("Chromium Plating of Motor Cylinders," *Metal Ind., N. Y.*, Vol. 38, Feb. 1940, pp. 76-78) chromium-hardening (hard-chromium plating) of cylinder bores reduces the wear of piston rings by as much as 75%. The chromium deposit applied is porous—more porous than coarse-grained cast iron. Oil adheres to this because it simply fills the holes. This highly porous chromium prevents scoring, and can also be honed.

The corrosion-resistance and friction coefficient of the hard-chromium deposit, together with its hardness to a lesser degree are responsible for the success of this process. Tests with ordinary alloy iron cylinders, with a nitrided liner and with a hard-chromium-plated bore (the nitrided and hard-chromium surfaces each about 1000 Brinell) showed the cylinder wear rate of the chromium-hardened bore to be 1/70 the alloy iron cylinder, and 1/10 the nitrided liner. Chromium-plating also effected a large reduction in the wear of the top piston ring.

Heavy nickel electrodeposits are also being increasingly applied to build-up undersized or worn parts, in producing wear-resisting surfaces and in electro-forming. Some of the requisite properties of nickel electroforms and methods of producing them are discussed by L. Weisberg ("Rapid Methods for Heavy Nickel Plating," *Mo. Rev. Am. Electroplaters Soc.*, Vol. 26, Dec. 1939, pp. 929-936). Heavy nickel deposits for engineering purposes should have enough strength and toughness to ensure satisfactory behavior in machining and when subjected to wear in service. Ductility and hardness may also be specified within given limits.

An important advantage of heavy nickel deposits of this type is the possibility of controlling the mechanical properties over a very wide range. By simple modifications in plating conditions, tensile strength may be varied from 50,000-130,000 lbs./in.^{2} and Brinell hardness from 125 to 500. The solutions most commonly used are of the Watts type (nickel sulphate, nickel chloride and boric acid) although all-chloride solutions offer promise of providing somewhat better efficiency of operation and quality of plate. X (3)

3a. Ferrous

Galvanized Steel Roofing

"Quebec Likes Steel Roofing."
Charles Matthews (Am. Zinc Inst.)
Sheet Metal Worker, Vol. 31, Jan. 1940,
pp. 70-71. Descriptive.

It is estimated that at least 60% of all roofing in the province of Quebec is galvanized metal. Of the remainder, about 35% is wood and the rest composition material. About 75% of the newer installations are metal.

The types in use vary from metal shingles to corrugated, V-crimped or special-style sheets. The newer roofs are of a special narrow, somewhat shallow corrugation, with a relatively high longitudinal rib at intervals of 8 in. Metal roofs are found not only on rural and industrial buildings, but also on rural, suburban and urban homes, besides churches, schools, community houses, etc.

The popularity of metal roofs is due to the development of a high grade galvanized sheet known as "Council Standard," having 75-200% heavier zinc coating than that used formerly. Each sheet made according to the Council Standard specifications is so marked. A small extra charge is made for this type of sheet metal, but the extra durability obtained more than compensates for it.

Complaints of the failure of sheets

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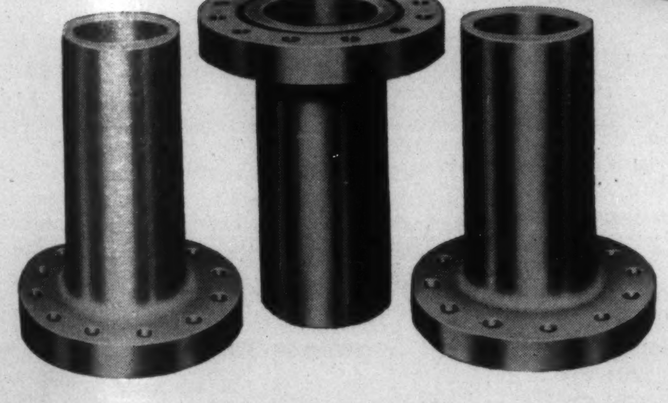

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Copper Alloy Cast Irons

Application of iron	Composition								Tensile Strength, lbs./in.²
	Total C	Si	Mn	Cu	Cr	Mo	V	Ni	
Cylinder blocks	3.15-3.40	1.80-2.10		0.75					30-36,000
Flywheel	3.30-3.60	1.40-1.80	1.00-1.25	0.75					32-38,000
Gears	3.20-3.40	1.40-1.60		1.25-1.75					34-40,000
Heavy machinery	3.10-3.30	1.40-1.80		1.75-2.25					38-45,000
Pumps, etc.	3.10-3.50	2.20-2.50		0.80-1.20	0.25-0.50				30-40,000
Brake drums	3.15-3.40	1.80-2.10		1.25-1.75	0.40-0.60				35-45,000
Heavy brake drums	3.20-3.30	1.70-2.40		0.75-1.25		0.40-0.60			40-50,000
Diesel cylinders	2.80-3.10	1.90-2.60	0.80-1.25	1.75-2.00		0.50-1.10			50-80,000
Brake drums, metal molds, etc.	3.10-3.25	1.80-2.20		1.75			0.25-0.35		45-60,000
General machinery	3.20-3.60	1.80-2.00		0.75-1.00				0.75-1.00	30-38,000

through rusting have stopped as have the claims that the galvanized sheets of the "olden days" were better than those offered today. Consumers, confidence restored, are returning to the purchase of galvanized steel in great quantity throughout the province. [In the United States, the amount of steel roofing in use is understood to be relatively small, owing to the steady inroads of other materials over a period of years. The extent to which improved quality of the galvanized sheet may help to overcome antipathy in our building industry to metal roofing remains to be seen.—F.P.P.]

PCR (3a)

Thermal Expansion of Alloy Steels

"Thermal Expansion of Some Chromium-Vanadium Steels." Peter Hidnert. *J. Research, Natl. Bur. Standards,* Vol. 24, Jan. 1940, pp. 25-32. Research report.

Data on the linear thermal expansion of several S.A.E. chromium-vanadium steels have been published previously. The present research gives the results of an investigation on the linear thermal expansion of two other S.A.E. chromium-vanadium steels (S.A.E. 1625 and 6150) in the annealed condition and in the quenched-and-tempered condition. These steels were investigated at various temperatures between 70° and 1200° F.

The coefficients of expansion of the hardened sample tempered at 400° F. or 800° F. are less than the coefficients of expansion of the annealed sample. Tempering at 1200° F. increased the expansion to that of the annealed sample. For the range from 70° F. to 1200° F. the average coefficients of expansion of all of the samples investigated vary from 7.7 x 10^{-6} to 8.2 x 10^{-6} per degree F. More specific data on the average coefficients of expansion per °F. x 10^{-6} are given in the table below.

WAT (3a)

Steel S.A.E. No.	Heat Treatment	Expansion Coefficients		
		70° to 212° F.	70° to 750° F.	70° to 1200° F.
6125	Annealed at 1650° F.	6.8	7.6	8.1
6125	Oil-quenched from 1475° F., drawn at 400° F.	6.7	7.2	7.7
6150	Annealed at 1575° F.	6.9	7.7	8.15
6150	Oil-quenched from 1575° F., drawn at 800° F.	6.95	7.8	8.2
6150	Oil-quenched from 1575° F., drawn at 1200° F.	6.85	7.7	8.2

Copper Cast Irons

"Copper in Cast Iron." Tom Barlow (Copper Iron & Steel Development Assoc.) *Iron Age,* Vol. 145, Jan. 25, 1940, pp. 19-22; Feb. 1, 1940, pp. 40-43, 77-78. Descriptive.

Until recently the use of copper in gray cast iron has received little attention, although such use is expanding. Sufficient data are now available to show what copper does when added in small percentages. Copper in cast iron is essentially a mild graphitizer or chill reducer—about ¼ as potent in this respect as silicon. At the same time, copper tends to harden and strengthen the matrix, an advantage not offered by silicon in the usual amounts in high-carbon iron.

The chill-reducing effect of copper is particularly useful in light castings; up to 1.5% Cu has proved very effective in such cases. Copper has practically no effect on the breakdown of pearlite. Although it reduces chill in lighter sections, it does not weaken or soften heavy sections of the same casting. Because copper is effective in breaking down excess carbide, reducing chill corners and eliminating hard spots in cast iron, it reduces the hardness of light sections which would otherwise tend to be mottled or white. At the same time, it strengthens and hardens the pearlitic matrix and refines the graphite structure in heavy sections.

The structure-stabilizing effect of copper is equally applicable to many other castings requiring density, machinability and uniformity, such as pump castings, fly wheels, sheaves, cylinder heads, etc. An interesting application of the graphitizing effect of copper is the Ford Motor Co. camshaft, the prime requisite for which is control of chilling to give a white cam tip and gray shafts without the use of external chills. This is done by replacing a large percentage of silicon with copper.

The ability of copper to refine graphite, increase density and decrease section sensitivity, and its beneficial effect on machinability and chill, warrant its use in combination with such carbide formers as molybdenum, vanadium and chromium. Some analyses and applications are given in the table above.

If the degree of chill is to be unaffected, copper and chromium should be in proportions of 4 to 1. Additions of chromium alone strengthen and harden cast iron, but render it brittle and difficult to machine. For most economical increases in tensile strength and other physical properties, copper-chromium and other alloy combinations should be added to pearlitic or balanced base irons, when possible. The copper-molybdenum combination is used extensively where high strength, wear resistance and toughness are required. If chill depth is to remain constant, copper and molybdenum should be added in equal proportion, the exact ratio depending on the carbon content.

Copper is often used in cast iron for special purposes, especially heat and corrosion resistance. One of the better known alloys contains 14-18% Ni with 4-7% Cu. Another corrosion resistant alloy iron contains 0.75-1.50% Cu. A new complex alloy cast iron utilizing the effect of copper on transformation rates contains 3-4% Cu, 1-2% Mn and 0.5-1% Mo. Care should be exercised to keep the copper below 2.5-3.5% unless special application calls for some free copper in the iron or unless a large amount of nickel (which increases copper solubility) is present, as in the case of Ni-Resist.

VSP (3a)

Stainless for Aircraft

"Stainless Steel for Aircraft Structures." H. W. Perry. *Aircraft Production,* Vol. 2, Feb. 1940, pp. 35-37. Abstracted in *Nickel Bulletin,* Vol. 13, Feb. 1940, pp. 45-47. Review.

Owing to the toughness, work-hardening qualities and other properties of 18/8 stainless steel, a somewhat specialized manufacturing technique has been found necessary in adapting it to aircraft construction. The experience of Fleetwings, Inc. shows, however, that initial costs involved in stainless steel construction are absorbed after about 50 structures have been produced, and that 100 parts cost less to fabricate than the same parts made from aluminum alloy. Among recent products of this Company are full cantilever-type wings and control surfaces for Seversky pursuit planes, and wing-tip floats for the Douglas Dolphin seaplane. In addition, the Fleetwings Sea Bird amphibian, developed for the commercial market, has a basic structure composed entirely of stainless steel.

Since the 18/8 stainless steel has more than three times the strength of 24 ST Alclad aluminum alloy per sq. in., and

Read what a user says*

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"We can cold draw anything in DUCTILOY *that we can draw in ordinary deep drawing steel or ingot iron."*

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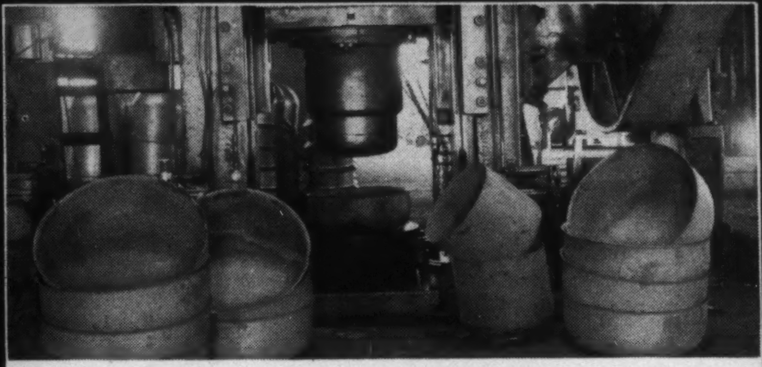

Dome End Shells cold drawn from DUCTILOY having physical properties of 55,240 lbs. per sq. in. Yield Point; 80,390 lbs. per sq. in. Tensile Strength and 36% Elongation in 2 inches.

This statement about DUCTILOY, taken from a letter recently received, is only one of many made by enthusiastic and satisfied users of this truly remarkable high tensile steel.

These Dome End Shells, made of DUCTILOY, 18⅛ inches deep with a diameter of 20 inches, were cold drawn from 44-inch diameter blanks by .134 gage, in two drawing operations—a tough job for even the best deep drawing quality of mild steel. *But this is just another one of the many cases where the unusual ductility of* DUCTILOY *has won unqualified approval.*

DUCTILOY will do an outstanding job for *you*. For parts and products such as these Dome End Shells, where a high tensile steel is desired, ordinary high tensile steels often fail because they don't have the necessary ductility to permit successful deep drawing and cold forming operations. But DUCTILOY, because of its unusual ductility, can be cold formed readily, easily, in most cases without intermediate annealing or changes in regular shop practice.

In DUCTILOY you get extremely high resistance to impact and fatigue, at normal as well as low or sub-zero temperatures, in addition to excellent resistance to abrasion and corrosion. This means that you give your products the necessary stamina to make them stay on the job longer with low maintenance costs.

A Great Lakes engineer will be glad to call and give you advice on where you can use DUCTILOY to advantage.

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weighs only 2.86 times as much per unit volume, the sheet thickness of stainless required to give equal weight, with greater strength, is approximately one-third that of the aluminum alloy. Full advantage of the strength-weight ratio can best be obtained in large structures, such as flying boats weighing 20,000 lbs. In such structures the thicker gages can be used, whereas in smaller craft minimum thickness is determined by the handling qualities and requirements of local stiffness.

Permissible compression stresses fall off rapidly with decrease in thickness, *e.g.*, some sections formed from 0.035 in. material show an allowable compression stress up to 187,000 lbs./in.,^{2} as compared with 60,000 lbs./in.^{2} for sections 0.006 in. thick.

In addition to its strength and fatigue-resisting qualities, which are of primary importance in aircraft construction, nickel-chromium stainless steel is characterized by other physical properties which are advantageous. Its high electrical resistance (6-8 times that of mild steel), its low thermal conductivity, good elongation and hard, clean surface are favorable to fabrication by spot-welding and to the strength of the completed welds.

In spot-welding very thin sheets, the fusing temperature is reached almost instantaneously, and considerably less current is required than for welding mild steel or aluminum. The surface of the sheets needs no protective coating when working, as the metal has a uniform resistance to corrosion throughout, and is so hard that it is not scratched by steel chips and particles. Elongation permits many kinds of fabrication, and distributes tension uniformly among the weld spots, the resulting structures requiring no heat treatment or other attention to the welds.

The present tendency in aircraft production is toward absorbing stresses in stringers and relying on thin enclosing skin to restrain the stringers. For a given weight, the greatest compression loads are carried by structures having the stiffest stringers and thinnest skin. A large amount of local stiffness in the skin is, however, desirable in the leading edge of wings, in split flaps, fuel tanks and other parts where pressure is heavy. In this respect the advantage appears to be with aluminum, since it is 2½ times as thick as stainless steel for equivalent weight and, assuming that stiffness increases as the square of thickness, is approximately 6½ times as stiff as stainless steel skin. To overcome this disadvantage, the following technique has been developed by Fleetwings, Inc., for use on stainless steel:

Stainless steel sheet 0.005 in. thick was formed into corrugations 3/16 in. deep and of ⅝ in. pitch, and spot-welded to a flat sheet of the same thickness, making a skin ¼ in. thick, which was bent to the leading edge of the wing panel. On test, this assembly showed 5 times the stiffness of the aluminum alloy sheet it replaced. For equal weight, the aluminum alloy sheet commonly used for leading-edge covering, including one coat of red oxide and two of heavy gray enamel on one side, would have a thickness of 0.028 in.

A unique feature of the Fleetwings design is that fuel tanks form part of the lower skin of the wings and are built to carry the necessary stresses. Corrugations in the side metal prevent bulging. Joints are made liquid-tight by seam- or spot-welding and filling the joint with solder.

In order to expedite the welding operations, a special spot-welding apparatus has been developed, capable of making 240, 480, or 960 spots per min. The corrugated sheet is placed on a copper grid, a flat sheet of stainless steel is stretched over it until all sags and wrinkles are smoothed out, and a pair of heavy rolling clamps is lowered into place on to it, to prevent twisting of the sheet. Finally, the welder electrodes are lowered into contact with the flat sheet and welding is carried out.

Wing panels constructed by these methods are very rigid torsionally. The corrugations are resistant to shear and therefore form no diagonal field of tension, and no part of the shear load is taken by the skin covering. The elastic center of the panel is close to the center of pressure of the wing, with the result that, in flight, stresses developed by the loading of the wing are in the nature of simple bending, rather than torsional, stresses. (3a)

3b. Non-Ferrous

Copper in Locomotive Fireboxes

Copper in Locomotive Fireboxes ("Le Cuivre dan les Foyers de Locomotives") Gaëtan Py. *Tech. Moderne,* Vol. 31, Nov. 1/15, 1939, Supplement, 8 pp. Review.

Copper is and has been used for over 100 yrs. for locomotive fireboxes in every country except the United States. American engineers prefer steel, owing to its lower first cost, and in spite of the saving in operating cost (3-5% saving in fuel) that is possible with copper. The use of deoxidized copper allows welding during fabrication as well as for repairs.

Although the tensile strength of copper averages less than 30,000 lbs./in.^{2}, it is

30Ni-20Cr
22Ni-20Cr-3Mo
25Cr-12Ni
27Cr-4Ni-1½Mo
18-8-SMo
12Cr
20Cr-10Ni
Cr
18Cr-8Ni
Ni
Ti
18-8-S
56Ni-22Cr
Mo
Se
Cr
Ni

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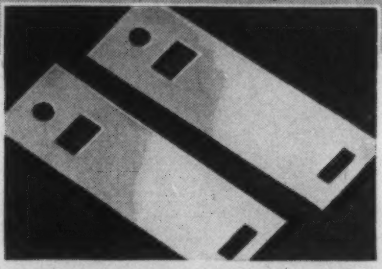

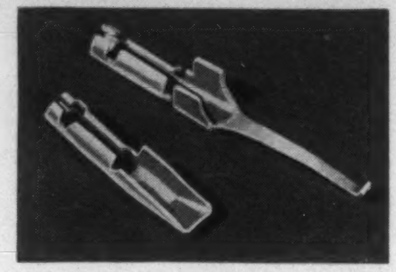

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NAME	*Hardness (Rockwell B) Wrought*	*Conductivity (% of Copper) Wrought*	*Ultimate Strength (psi) Wrought*	*Elongation (% in 2") Wrought*	*Proportional Limit Wrought*	*Annealing Temperature °C.*	*Annealing Temperature °F.*
Elkaloy A	50-75	85	65,000*	20	20,000	350	660
Mallory 3	75	80	70,000*	15	32,000	500	932
Mallory 333	80	80	75,000*	15	35,000	500	932
Mallory 22	80	80	75,000*	15	35,000	450	840
Mallory 53	95	40	95,000	10	55,000	550	1020
Mallory 73	40-C	23	170,000	4	100,000	375	710
Mallory 84	95	50	100,000	8	75,000	600	1110
Mallory 100	95-100	50	100,000	10	80,000	500	932
Copper	40	100	40,000	35	7,000	200	392

**Average for bars up to 1" in diameter.*

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NON-FERROUS ALLOYS and ELECTRICAL CONTACTS

adequate for all service. The copper is less attacked in service than the steel; also, it is not necessary to purify the water as with steel. Owing to its superior thermal conductivity, the copper equalizes and reduces the temperature. Recently, copper with 1% of elements such as arsenic, nickel and silicon has been used because of its better strength. It is stated that these fireboxes form a large and easily accessible reserve of copper for war time use if necessary.
JZB (3b)

New Aluminum Applications

A Composite

Some interesting applications—actual and proposed—of aluminum alloys are reported in several recent publications, some of which also offer useful reviews of the general properties and serviceabilities of such alloys.

Although about 850 aluminum alloys were listed by A. von Zeerleder in Gmelins Handbuch, the number that are really useful may be reduced to about 24, he believes ("Light Alloys of Aluminum," *Metallurgia,* Vol. 21, Dec. 1939, pp. 47-53). Of these 24, about half are wrought alloys and half casting alloys, and each of these groups may be subdivided into hardenable and non-hardenable alloys.

The alloy of the composition developed by Wilm in 1906 (Duralumin) is still important, although it has been largely superseded by stronger modifications. The so-called Rolls-Royce alloys are also highly valuable. It is pointed out that some aluminum castings are cheaper than iron castings designed to do the same job even though aluminum is an expensive metal. The advantage of weight saving made possible by aluminum in transportation equipment is stressed.

One field of transportation in which aluminum alloys find growing application is the marine field. The use of such alloys in ship construction because of their low weight and low modulus of elasticity is discussed by A. Brinck ("Aluminum in Shipbuilding," *Motor Ship,* Vol. 20, Feb. 1940, pp. 392-394). The more recently developed alloys are characterized by better corrosion resistance. The weight reduction effected in the superstructure and other parts including machinery is considered for various types of ships, particular reference being made to the dimensions and quantities of aluminum plates and angles used in the construction of the *Fernplant.*

For joining light metal structures of various types steel bolts are still employed, although the use of light metal bolts would mean great weight-saving and would practically eliminate local element corrosion. The behavior of light metal bolts under static and dynamic forces was therefore investigated by F. Bollenrath, H. Cornelius & W. Siedenburg ("Festigkeitseigenschaften von Leichtmetallschrauben," *Z. Ver. deut. Ing.,* Vol. 83, Nov. 4, 1939, pp. 1169-1173).

Two aluminum-copper-magnesium alloys containing (a) 4.35% Cu. 1.2 Mg, 1.35 Mn, 0.57 Si, 0.42 Fe and a trace of Zn; and (b) 4.12% Cu, 0.95 Mg, 0.65 Mn, 0.37 Si, 0.42 Fe, 0.2 Zn and 2.10 Pb were made into bolts of various diameters and tested. In general, the light metal bolts are equivalent to steel bolts. It is not advisable to eloxate or to chromium-plate light metal bolts. Greased bright steel bolts require for the same tension about 1.3 times the force as do the un-eloxated, greased light metal bolts.

The Norwegian packing industries have for some time been using aluminum containers for various fish products, says G. Lunde ("Aluminium als Verpackungsmaterial für die Konservenindustrie," *Aluminium,* Vol. 21, Dec. 1939, pp. 843-845). Aluminum of 99.5% purity has been highly successful. The same type of material can be used also for slightly acid foods like tomatoes and berries if anodized or lacquered. The amounts of aluminum absorbed by the food in aluminum cans were found to be no greater than the harmless pick-up that occurs when cooking in aluminum utensils. Because of its softness, aluminum is more amenable to one-operation deep drawing than is tinplate, but the softness also requires greater care in sterilizing and pasteurizing to avoid cracking the cans.
X (3b)

Wrought Duralumin Crankshafts

"Wrought Duralumin Crankshafts." *Light Metals,* Vol. 2, Mar. 1940, p. 78. Speculation.

The replacement of iron and steel for crankshafts by aluminum alloys will need careful investigation. Larger diameters and hence larger bearings and housing will probably be necessary. Nevertheless, there remains the distinct possibility that such an application will develop. The endurance limit of duralumin is practically equal to that of the high-grade cast ferrous metal used in Ford crankshafts.

In order to obtain a bending stress in duralumin equal to that of a plain carbon steel of 72,000 lbs./in.^{2} tensile strength, it is necessary to increase the section 22%. This would theoretically yield a weight reduction of 45%. Naturally, stress conditions are not the sole factors to be considered in visualizing a change from steel to duralumin; there is the problem of providing a suitable bearing material. Tin-

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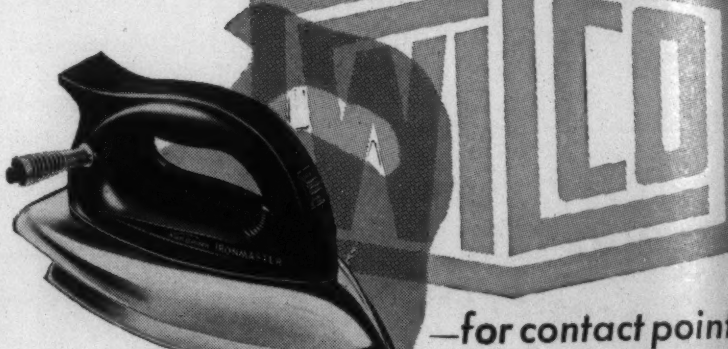

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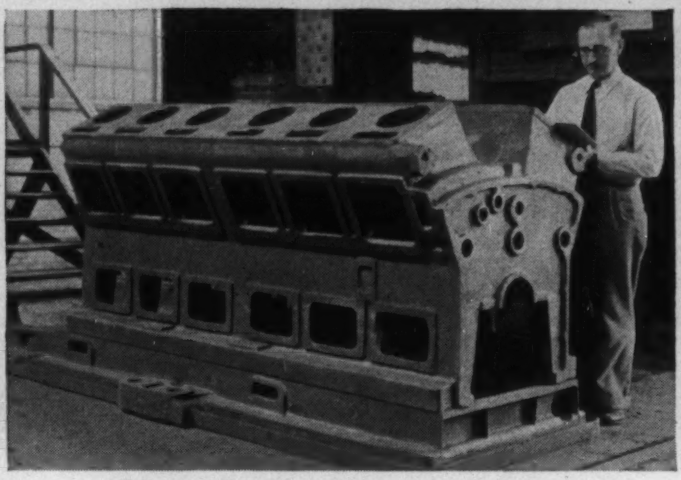
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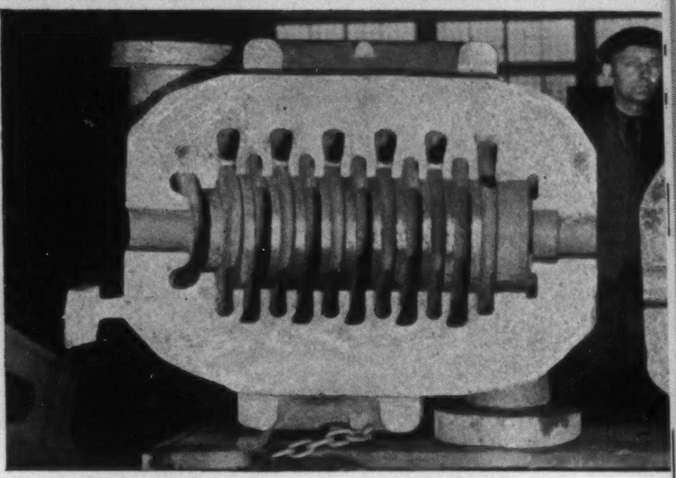
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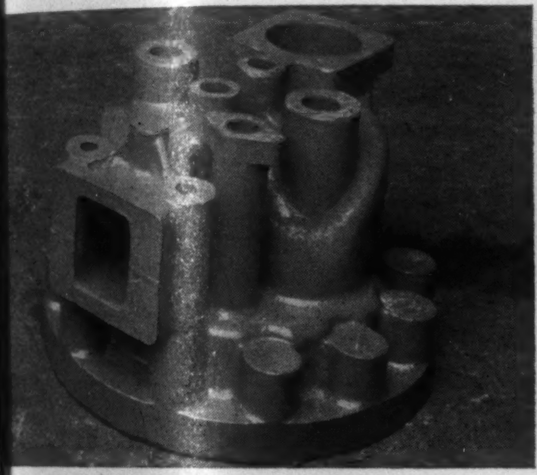
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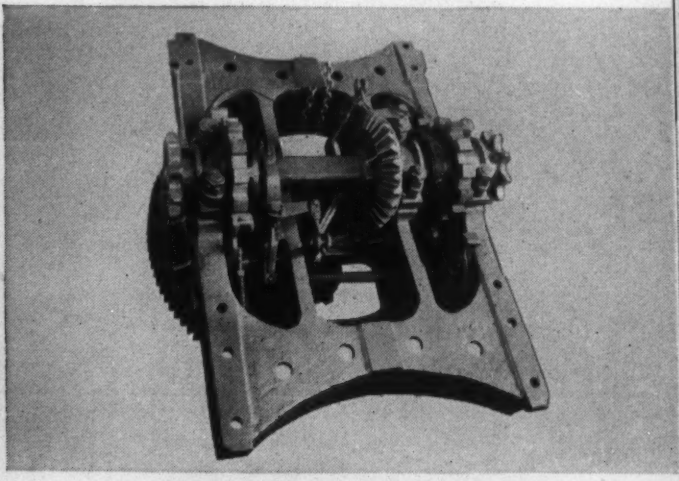
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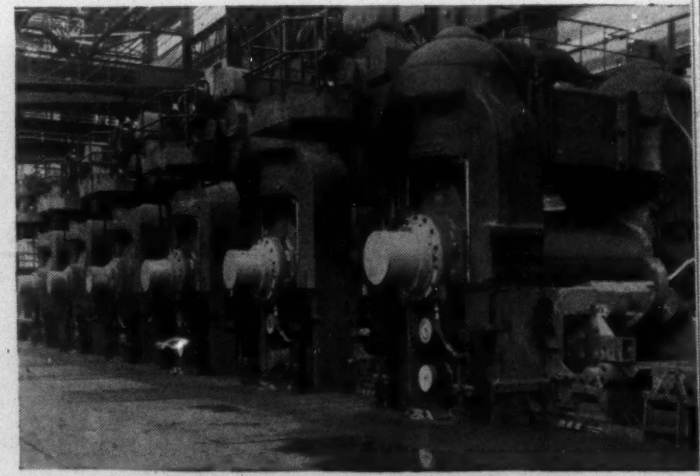
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base alloys and leaded coppers are not satisfactory as bearings with duralumin. However, tests by D.V.L. using a sleeve of phenolic resin over the duralumin surface have indicated satisfactory running capacities. AUS (3b)

Magnesium Alloys in Aircraft

"Magnesium Sheet for Aircraft." L. B. Grant. *Aviation,* Nov. 1939, pp. 36-37. Review.

The author feels that "engineers in this country have been prone to use and treat magnesium alloys exactly like aluminum, with the result that magnesium was given the reputation of not being suitable for a particular application." A table presents the compositions, relative resistance to salt water, characteristics and uses of some 18 magnesium alloys containing aluminum, manganese, zinc, silicon and cadmium.

Condition	Tensile Strength, lbs./in.²	Yield Strength, lbs./in.²	Elong. % in 2 in.	Hardness, Rockwell "E"	Brinell Hardness
Hard-rolled	37,000	27,000	9	64	53
Annealed	32,000	16,000	15	56	48

Among these, a magnesium-manganese alloy with 1.5% Mn is the most widely used composition in sheet form, extruded sections, sand castings, and forgings of moderate strength. It is weldable with the oxyacetylene torch, and has the the best salt water resistance and physical properties, as given in the Table. Detailed instructions on bending operations are given. Magnesium or aluminum dies should be used instead of the regular lead and zinc dies to prevent pick-up at the drop forging temperatures. The female die should be heated to 400° F. and the sheet to 700° F. Above 800° F. grain growth occurs. Drawing speed should be less than for other metals.

Aluminum rivets should be used in riveting to aluminum, and rivet holes should be punched and not drilled. After assembly, magnesium alloys should be painted wherever possible. A weldable alloy for die castings combining good casting characteristics with best mechanical properties analyzes 9.0% Al, 0.2% Mn, 0.6% Zn, remainder Mg. The following magnesium alloy is recommended for hammer forging: 2.5% Al, 0.3% Mn and 3.5% Cd. EF (3b)

Leaded Aluminum Alloys

Lead Bearing Aluminum-Magnesium Alloys ("Ueber bleihaltige Aluminium-Magnesium-Legierungen.") Heinrich Bauer. *Aluminium Archiv.,* No. 24, 1939, 30 pp. Investigation

Because an efficient free-cutting light metal alloy has long been needed, the possibility of finding it in lead-bearing aluminum alloys was studied. The ternary aluminum-magnesium-lead diagram shows a field of liquid immiscibility and a field of easily decomposing solid alloys, reaching up to 50% Mg. The decomposition of these alloys is caused by the compound Mg_2Pb, unstable in air. Aluminum-magnesium alloys with 10% Mg can incorporate up to 3% Pb in uniform fine distribution.

In the experiments to develop a free-cutting aluminum-magnesium alloy, alloys with 1-5% Pb and 3-11% Mg were studied as regards tensile properties, lead distribution, effect of cold working on the mechanical properties, suitable annealing treatment, microstructure, machinability and corrosion behavior. Lead contents up to 3% can be added to an aluminum-magnesium alloy with 7% Mg. Given proper melting and casting conditions, no segregation is apparent with lead contents up to 2.5%. The maximum solubility of lead in liquid aluminum amounts to 13% at 1750° F. The point of introduction of the lead, *i.e.* whether before or after the magnesium addition, has no effect on the uniformity of the lead distribution.

The tensile properties of lead-bearing aluminum-magnesium alloys with 7% Mg—except for a decrease in elongation—are scarcely affected by increasing the lead content, up to 2.5%. The course of the curves depicting the dependence of the mechanical properties on the degree of cold work show that the deformation capacity is actually improved by lead. An annealing treatment between 300° and 500° F. tends to increase the heterogeneity of these alloys. The effects of cold work are completely obliterated at 575° F. Cold working impairs machinability. Either by annealing (precipitation range) at 400°-500° F., or above the melting point of lead, at about 650° F. (solution range), the desired short chips for free cutting are obtained.

The alternate bending fatigue strength of a 7%-Mg, 2.5%-Pb aluminum alloy amounted to 21,000 lbs./in.² for extruded rods, 22,700 lbs./in.² for drawn rods and 11,300 lbs./in.² for notched samples. Salt spray corrosion tests prove the corrosion stability of lead-bearing free-cutting aluminum-magnesium alloys to be practically identical with the corresponding lead-free alloys. The amenability of these lead-bearing aluminum-magnesium alloys to anodic oxidation and to polishing meets all requirements. GN (3b)

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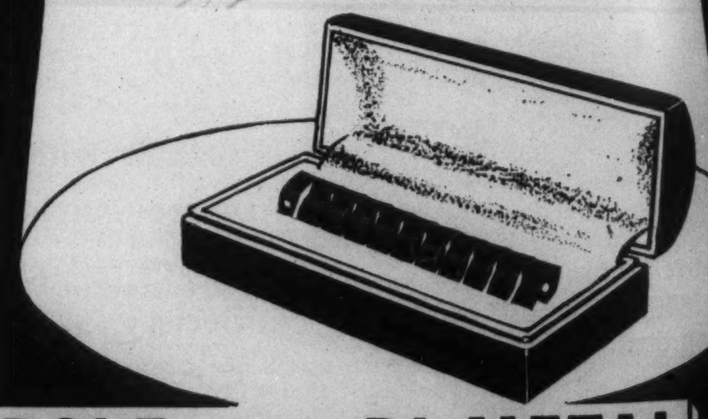

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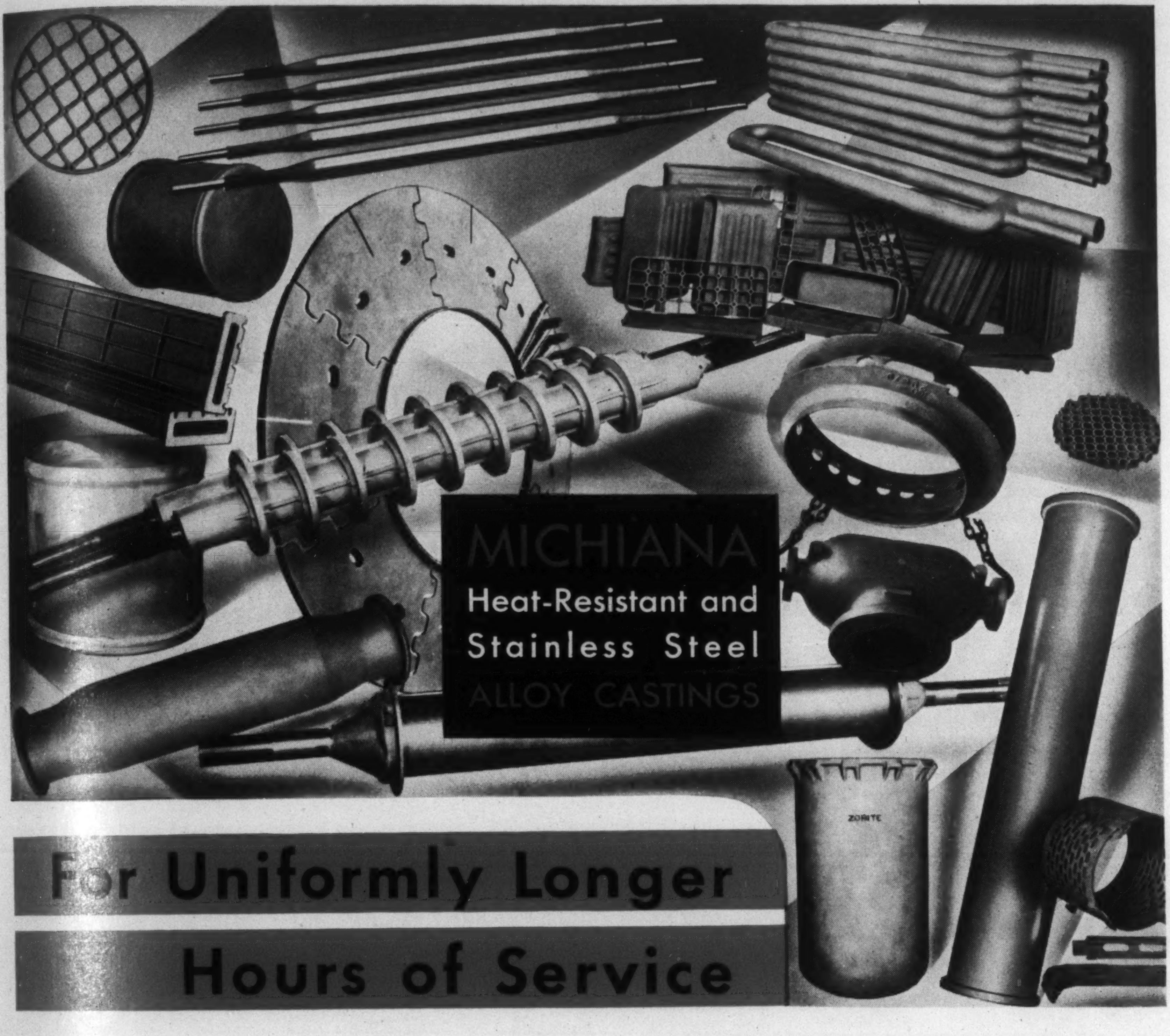
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Furnace Atmosphere Control

"AUTOMATIC CONTROL OF FURNACE ATMOSPHERE." H. M. WEBBER (Gen. Electric Co.) *Instruments*, Vol. 13, Mar. 1940, pp. 73-76. Well-illustrated descriptive review.

Heat treatment and brazing are today performed to a great extent in controlled atmosphere furnaces. These atmospheres are completely independent of the heat source and are supplied and controlled by use of auxiliaries generally mounted alongside the furnace. The choice of suitable furnace-atmosphere equipment and accessories depends on the nature of the metal treated, the nature of the treatment itself, and the results that must be produced.

A typical combustion-type furnace-atmosphere controller for partly burning hydrocarbon gases consists of a combustion chamber with suitable burner and fire check; visual flow-meters for measuring the rate of input of air and gas and checking their ratio; motor-operated gas-combustion controller for maintaining constant input ratio and pressure to the burner; and a surface cooler to cool the product gas to approximately the temperature of the available tap water and thus reduce the moisture content of the gas to a dew point corresponding to that temperature.

The combustion chamber contains a firing bed of suitable refractory material which has been treated with a catalyst. The lining of the combustion chamber is designed for the service intended, it being more heavily insulated for low-ratio operation than for high-ratio operation. For low ratios, less heat is developed than when the machine operates at nearly complete combustion. Operating on low ratios produces gases rich in hydrogen and carbon monoxide highly suitable for bright annealing, scale-free hardening and electric-furnace brazing of ferrous and some nonferrous metals. Operation at high ratios, which develops gases containing practically zero hydrogen and carbon monoxide, is necessary for bright annealing copper if the copper includes oxygen, in order to avoid embrittlement of the copper.

For some processes the moisture content must be further reduced or completely eliminated. This may be done by cooling with a refrigerator and by complete removal with an adsorber such as an activated-alumina dryer. Although either of these devices is suitable for partial removal of moisture, the refrigerating equipment is generally used if the dew point does not need to be reduced below 40° F. For complete removal, the activated-alumina dryer is commonly employed, although in some cases it is economical first to refrigerate the gas, then dry it.

A typical refrigerating unit consists of a condensing unit and an insulated cooling tank filled with a solution of water and alcohol. In this tank are two coils, one for the refrigerant from the condensing unit and the other for the gas to be cooled. Thus, the refrigerant cools the bath and the bath in turn cools the gas. The temperature of the bath is thermostatically controlled.

A typical activated-alumina dryer consists of two electrically-heated chambers filled with activated alumina, with suitable valving arrangement so that gases to be dried pass through one chamber only, while the other chamber previously used is being reactivated by means of thermostatically-controlled electric heat which drives off the moisture with the help of a blower.

For checking the moisture content of gases before they enter the furnace, a dew-point potentiometer is frequently used. A small stream of gas is conducted through a compartment in the instrument where it comes into contact with a thin metallic mirror to which a thermocouple is attached. This thermocouple is connected to a potentiometer and to an indicator the scale of which is calibrated in degrees of temperature. In taking a measurement, the operator increases the flow of cooling gas (from carbon dioxide bottles) against the back of the mirror until a spot of moisture condenses on its surface. Slight adjustment of the cooling effect will then cause the alternate evaporation and condensation of moisture on the mirror. At that point the dew-point temperature can be read directly on the indicator after balancing the galvanometer by turning a knob.

Sulphur-purification equipment consists of a water-spray tower and an iron-oxide tower connected in series. The gases to be purified enter the chamber at the bottom, rise in contact with the down-pouring water and leave at the top. Carbon dioxide can be removed by the use of a liquid absorber which dissolves carbon dioxide and holds it in solution. Upon subsequent heating, the carbon dioxide is driven off. The liquid is cooled and is again ready for use, thus making the process continuous and regenerative.

For some types of furnaces, particularly those with liquid or sand seals, it is necessary to supply the gas at low pressures—say 2 to 6 in. of water—so there is installed in the line to the furnace a pressure regulator to reduce and control the pressure. Often, too, the load on the furnace-atmosphere controller varies as retorts are continually cut in and out of the system. It is therefore necessary to install a relief valve in the output line in addition to the regulator. Then, if the load is reduced to a certain point, the back pressure builds up to the extent that the relief valve opens and discharges processed gas to the outdoors in sufficient volume to maintain the required combustion-chamber temperature. (4)

Hardenability Testing

"THE HARDENABILITY OF CARBURIZING STEELS." W. H. BRUCKNER (Univ. Illinois) *Univ. Illinois Eng. Exp. Sta. Bulletin* No. 320, Nov. 1939 (issued Mar. 1940) 62 pp. Research.

Methods of selecting steels according to their response to a standardized carburizing and hardening cycle have been favorably regarded by the automotive industry. One such method of wide interest is the Jominy-Boegehold hardenability test (see METALS AND ALLOYS, Vol. 9, Apr. 1938, p. MA 226 R 1). The aim of the present research was to investigate the hardenability of known low- and high-hardening steels of increasing alloy content, to determine whether the Jominy method of rating the hardenability of carburizing steels was valid.

The results of tests made on various S.A.E. steels in the carburized condition indicate that differences in hardenability are determinable by means of the Jominy test. Comparisons made between the hardenability as found at the $\frac{1}{8}$-in. distance in the Jominy bar and the hardenability found for 1-in. round carburized bars quenched in oil show that the hardenability that the Jominy test predicts is not entirely realized. There is a close correspondence of hardenability for the Jominy bar at $\frac{1}{8}$-in. from the water-cooled end and for the oil-quenched bar at a depth of 0.026 in.

The fundamental difference in the cooling rates over the cross section for the Jominy bar and for a bar quenched by total immersion is suggested as a possible reason for the differences in hardenability observed. The Jominy bar is so designed as to cool from the center of the cross section with a slight temperature gradient, while the fully-immersed bar cools from the outside surface and with a steep temperature gradient. The transformation of austenite therefore takes place in the latter case in a system of stress while the Jominy bar transformation takes place in a practically stress-free condition.

A comparison of the hardenability results obtained by means of the Jominy test and the Burns test (see METALS AND ALLOYS, Vol. 9, July 1938, p. MA 447 R 3) indicates that there is no consistent relationship between them for the S.A.E. 4615-4620 type of steel. The Burns test provides a critical cooling rate at the surface of the bar, and is used for steels of low carbon content, while the Jominy test provides a variety of cooling rates and is useful for steels of high carbon content and consequently of lower critical cooling rate. A prediction of the hardenability of the carburized Jominy bar can therefore not be made by means of the simpler Burns test on the uncarburized material. (4)

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Radiography of Auto Castings

"The Use of Radiography in the Development of Castings for Mass Production." D. M. McCutcheon (Ford Motor Co.) *Bull. Am. Soc. Testing Materials*, Mar. 1940, pp. 13-16. Review.

In the past few years the number of cast parts replacing forgings (or other fabrications) for automotive uses has consistently increased. In one month (Feb. 1939) Ford used 7100 tons of copper-silicon steel castings. Radiographic inspection methods play an important part in the development of improved foundry methods for this company by the use of cast models before the establishment of mass production.

Any part considered for production as a casting must show definite manufacturing advantages over an equivalent forging or assembled unit. In addition, the casting must have suitable structure, strength, hardness or other properties required by the use to which the part is subjected. A cast experimental part is given extensive physical and service tests before being accepted for production.

The experimental foundry casts a number of test models, using a foundry technique believed to be best suited for that particular design. Casting costs are not restricted, so adequate gates and risers are provided to insure a sound casting. A very careful radiographic examination of these test parts is made, and no casting is accepted for testing purposes unless perfectly sound. Very often a change in experimental foundry technique or a modification of the metal analysis is necessary.

The most economical foundry procedure is sought in the production foundry consistent with the production of sound castings. A minimum amount of return metal is desired together with the most efficient sand mold and core design. The radiographic methods and technique have all been carefully worked out and standardized, so that the maximum speed and sensitivity control are consistently secured. Radiographic examination is not used in general for inspection testing of production castings after development work is completed, but only as an aid in the development of such tests. Where production is only moderate, however, as in the cast brake and clutch pedals for busses, 100% X-ray inspection was made over a considerable period.

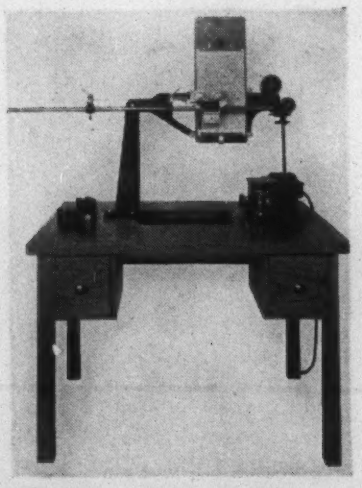
Castings designed for automotive use must be free from defects that are apt to cause any weakness in stressed parts. The radiographic method of examination easily detects gross defects, but it is in the detection of small defects such as very fine gas pockets or shrink cracks that carefully controlled radiographic procedures are required. The cast crankshaft is typical of the difficult shapes that must be radiographed both rapidly and carefully. A cavity sensitivity of 0.5% is maintained on the 2¼-in. dia. bearings. Experience has shown that this limit is necessary, particularly to catch small gas holes that might show up on machining and grinding of the bearing surfaces.

The time required for preparing a crankshaft for X-ray examination is 15 min., with an exposure time of 2½ min. for the 2¼-in. bearing section. If necessary, 2 crankshafts can be examined simultaneously in a total time of 25 min. Two high-speed intensifying screens are used in a standard lead-lined cassette using ultra speed type of film.

Castings having widely varying thicknesses of metal section, as in a cast camshaft, are examined by immersion in a saturated soluble lead salt solution. The sensitivity in this case is somewhat reduced due to the unavoidable X-ray scattering in the solution. When using the solution method, it is customary to expose the films to a higher average density than is used for objects such as the crankshaft. The addition of a small amount of acetone or similar organic liquid to the lead solution before immersion of the cast part reduces the tendency for gas bubbles to adhere to the surface of the casting.

The establishing of a radiographic sensitivity of 0.5% on 2-in. sections, which are subsequently machined and ground, has been found sufficient to catch all objectionable defects, however small. Every cast part is radiographed with a small penetrameter gage, of either the stepped type with holes punched in the center of each step, or the slotted type, as described in the A.S.M.E. Boiler Code. Where it is convenient to build up an artificial section of equal thickness adjacent to the part under examination, the slotted type of gage is used; otherwise, the stepped type of gage is placed upon the top of the important sections during exposure.

The detection of cracks by radiography is generally considered to be rather difficult. Magnaflux magnetic testing is used at the Ford Motor Co. as a supplement to the radiographic method for the detection of cracks in forged, welded and cast ferrous metal parts. Fortunately, the location and angle of casting cracks can usually be anticipated in small cast parts allowing most favorable positioning of the castings during radiography. Examination of suspected parts by both radiography and magnetic testing methods has shown that radiography is sufficiently reliable to detect most such defects. FPP (4)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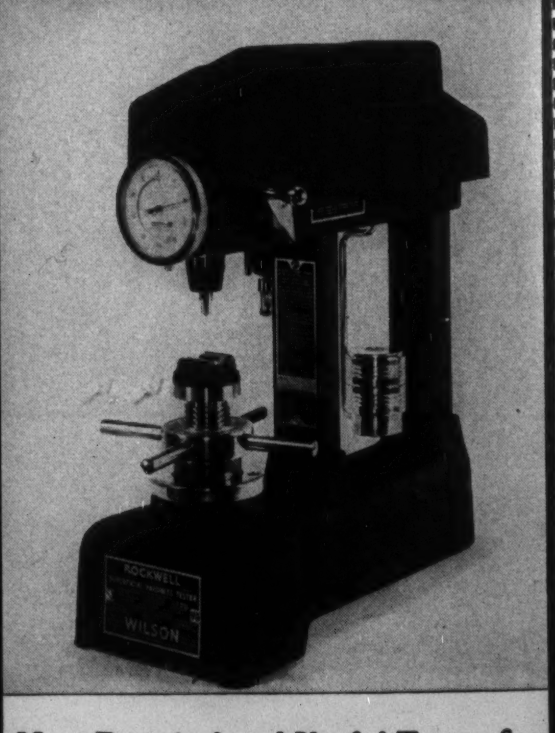
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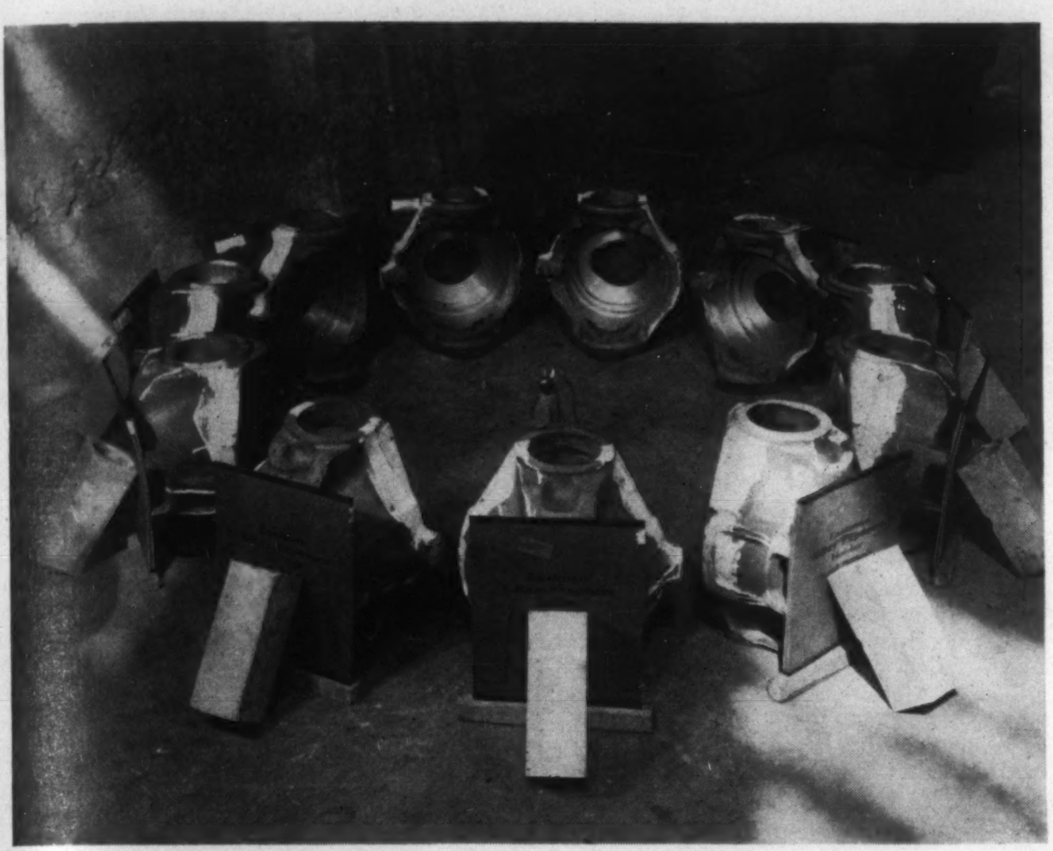

Courtesy Lebanon Steel Foundry

The quantity of radium used for industrial radiography is in units of from 25 milligrams to 500 milligrams. The silver capsule containing the radium is placed inside a duralumin container to facilitate ease in handling.

•

The only other equipment necessary is x-ray films and lead foil intensifying screens which are placed on both sides of the film within the film holder.

•

Note!

In the above illustration, the radium is in the center surrounded by eleven steel castings. One exposure takes eleven radiographs. The exposure time varies inversely with the amount of radium used, therefore the exposure required when using 200 milligrams is one-half the time when using 100 milligrams.

IN the gamma-ray radiographic set-up, the film holders are placed on the metal face opposite to the radium. The castings can be placed entirely surrounding the radium, as well as above and below. In practice the distance from the radium to the film depends upon the number and size of the castings to be radiographed at one time and upon the definition desired. Radium for non-destructive testing may be rented at very small cost.

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New Spectrographic Technique

"A New Spectrograph Testing Technique. Established at Pearl Harbor Navy Yard.' W. H. Hammond. *J. Am. Soc. Naval Engrs.*, Vol. 52, Feb. 1940, pp. 65-76. Descriptive.

The use and advantages of a new instrument provided with a concave reflecting metal grating, ruled with 48,000 1-in. lines over a 2-in. length are described. The advantages claimed over the quartz prism type are high resolution and wide dispersion, linear dispersion and ease of operation. A layout plan of the spectrograph room is shown to indicate a convenient arrangement for taking spectrograms, processing the film and projecting the spectra therefrom in a minimum of time.

The analyses are made by arcing samples mounted in graphite electrodes. It has been found that the lines photograph much more sharply, and the lens is less fogged, if the mist of metallic oxides which forms during a run is constantly swept away. A new "boiler" electrode is described; this is a closed capped electrode for use with an arc of 220-250 V. and is said to make the analysis as dependable as one made with a spark of 10,000-2,000 V.

The spectrographic method is suggested for identifying steels which become mixed in machine or forge shop, for impurities in foundry scrap, analysis of segregated portions of castings or regions of porosity. In one case, the detection of an aluminum oxide segregation by spectrographic means explained porous spots in gun metal castings. The detection of small amounts of tungsten, platinum and zinc in battery acids in the presence of iron is mentioned as a difficult problem that may be solved by means of the method. WB (4)

Temperature of Liquid Steel

Temperature Measurements on Liquid Steel in the Basic Open-Hearth Process ("Temperaturmätningar på flytande stål i basisk martinugn") Sven Fornander & Ture Omberg. *Jernkontorets Ann.*, Vol. 123, No. 11, 1939, pp. 527-44. Research.

A tungsten-molybdenum thermocouple was constructed and enclosed in a water-cooled pipe with a large enough flow to keep the water temperature rise below 63° F. To permit easy replacement the hot junction was inserted in a socket connected to the cold junction. The hot junction was inserted into Pythagoras tubes and covered with a graphite-clay mixture to prevent attack by slag and steel, and the whole junction protected aaginst breakage by enclosure in a graphite tube.

Temperature equilibrium was attained in 2½ to 3 min. The junction was effective for about 6 measurements. The measured temperatures were found to vary considerably from the heat of the charge as estimated by the operators. The authors therefore believe that temperature control by such thermocouples should insure greater uniformity of production. HCD (4)

Inductive Testing

Nondestructive Testing of Nonmagnetic Metals ("Zerstorungsfreie Werkstoffprüfung an unmagnetischen Metallen") R. Claren. *Metallwirtschaft*, Vol. 19, Jan. 12, 1940, pp. 27-28. Descriptive.

An apparatus developed at the German Gov't. X-ray Dept. at Berlin for the detection of cracks, pipes and other defects in tubes, rods or other symmetrical sections of nonmagnetic metals is described.

The inductive testing apparatus (called "Periflux") consists of a test coil through which the section to be tested is passed. The magnetic field set up by passing an alternating current through the coil produces circular current flow in the test piece. Any defect in the test piece when the test coil is passed over it causes a change in current flow in the test piece. The reaction of the circular current within the test piece is measured by a change in the resistance across the test coil. Any change in resistance denoting a flaw is readily detected and can be indicated acoustically.

In order to obtain the best results the inside diameter of the test coil should closely fit the part to be tested. In measuring stock varying from 10 to 80 mm. (0.4 to 3.1 in.), 3 different size test coils are used. GA (4)

Lead Metallographic Specimens

"The Preparation of Lead and Lead-rich Alloys for Microscopic Examination." Hill W. Worner & Howard K. Worner. *J. Inst. Metals*, 1940, Adv. Copy No. 863, 7 pp. Descriptive.

Specimens of lead or high-lead alloys are first cut with a hack saw. The deformed metal is then removed with a microtome. The sample may then be etched to remove recrystallized metal and then polished, or it may be polished without etching. Polishing is done on selvyt cloth using several grades of alumina prepared by elutriating in accordance with the method described by Rodda.

Etching is done in a solution containing 20 to 30% perhydrol and 70 to 80% glacial acetic acid. Fresh solution is used, but it generally works best after it has dissolved a small amount of lead. It is sometimes necessary to re-polish and re-etch. An example of the movement of a grain boundary during etching is shown. JLG (4)

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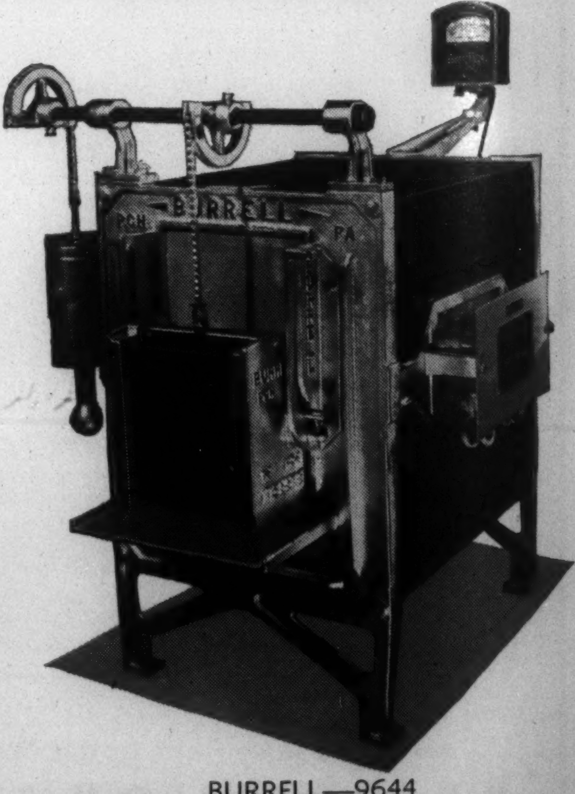
The heating chamber measures 4"x4"x13¼" deep. The floor is a removable, refractory plate with moulded sides to prevent spillage from reaching the insulation. Overall outside dimensions of the furnace are 26" wide x 30" high x 24" long. Weight, boxed for shipment, 400 lbs.

The heating elements are designed to give long life but when it is necessary to replace them this operation can be done in five minutes without cooling the furnace.

Other standard models include muffle types —combustion tube types—and pit types. More information on request.



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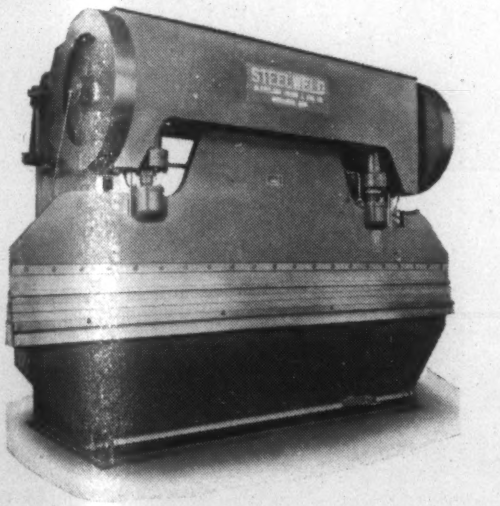
New Equipment and Materials

Bending Presses

A new series of Steelweld bending presses, adaptable for extensions of bed and ram at one or both ends, is announced by the Steelweld Machinery Div. of Cleveland Crane & Eng. Co., Wickliffe, Ohio.

The illustrated press, model H-8, is provided with 2-ft. extensions on each end. It normally handles plate 8 ft. x 5/16 in. between housings, but the extensions permit the forming of plate 14 ft. x No. 12 gage. Other presses in this series can take plate up to 20 ft. and thicknesses up to ¾ in.



The frames are of one piece all-welded construction, and are said to remain rigid for life. Bending, forming, blanking, drawing and multiple-punching operations may be performed on Steelweld presses.

Hard Facing Electrodes

The Lincoln Electric Co., Cleveland, announces two new hard facing electrodes which will be known as "Faceweld No. 1" and "Faceweld No. 12." These electrodes are cast abrasion-resisting alloys used for hard-facing by the metallic arc process. Both are described as coated electrodes, having exceptionally good arc characteristics and producing a smooth dense deposit. Deposits are very resistant to abrasion but not excessively hard and brittle. "Faceweld" bonds well with all types of ferrous alloys.

"Faceweld No. 1" is a general purpose hard-facing electrode and is the softer and tougher of the "Facewelds." It has good abrasion resistance and very high resistance to impact for this class of material. It is used for surfacing such parts as digger teeth, scarifiers, grader blades, cement plant machinery, etc., by arc welding. "Faceweld No. 12" is applied by arc welding and is somewhat harder than "Faceweld No. 1" and is said to have superior resistance to abrasion. Its resistance to impact is excellent for this type of material but not quite so high as "Faceweld No. 1" in this respect.

Applications include screw conveyors, conveyor sleeves, plows, gyratory crushers, power shovel and dragline bucket parts, dredge pump impellors and casings, coal pulverizer jaws, cement mill machinery, such as Bradley and Griffin rings, crusher roll plates, etc.

New Steel-Making Control Agent

"Grainal" is at last available and ready for distribution to steel makers interested in its effect on the quality of their steel. Grainal, developed by engineers of Vanadium Corporation of America, 420 Lexington Ave., New York, is the type name for a new series of addition agents for steel-making, which are said to confer on ordinary carbon steels and the very low-alloy steels the hardness and other important physical characteristics of more highly-alloyed steels—even when the Grainal is added in proportions as low as 2 lbs. per ton of steel.

Tests to establish the value of the combinations of alloying elements for steel used in the automotive, aircraft, machinery, armament and other industries requiring heat treated steels have been under way for many years. The Grainal series, originally ferro-alloys of vanadium, titanium and aluminum, were the subject of research for over 3 yrs. before actual field work was started over a year ago. The Grainal alloys, it is stated, have been tested in various large American steel plants, and the steels so produced have been subjected to rigorous scrutiny by many of the larger users of steel, such as the automotive and farm implement industries.

Steels produced with the help of Grainal are said to show remarkable uniformity and to possess hardness and other qualities hitherto obtainable only through the use of much larger quantities of other alloys. This degree of uniformity is not only of value in steel-making itself, but is highly important in the meeting of high specification limits, particularly for carbon and low-alloy steels. The manner of functioning of Grainal additions is described as distinctly different from that of alloys used in conventional alloy steels. Among the probable explanations for the benefits claimed to result from the use of Grainal are that in addition to simple deoxidation, the new Grainal alloys contribute to the fixation of nitrogen, whose presence has been recognized as contributing to variable results in finished steels of otherwise identical properties and composition.

It is worth noting that alloys of this type may be made from ores readily available in this country. Equally important, their employment could lead to greater economy in the use of higher-priced alloys, conserving the latter for use in the higher-alloy steels of which they are basic constituents.

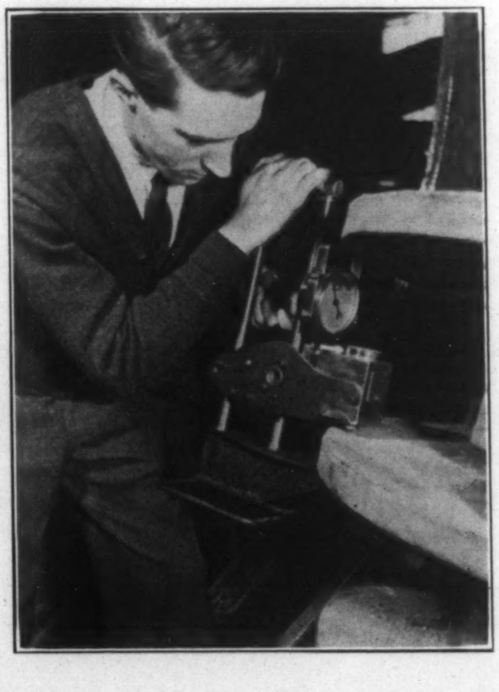
Refractory Radiant Tubes

Refractory heating tubes in annealing furnaces offer interesting possibilities, if the success of one operating installation in a West Virginia plant is any criterion. Developed by Gas Machinery Co., 16100 Waterloo Rd., Cleveland, the refractory radiant heating tubes in the furnace just mentioned are fired with low pressure natural gas in special diffusion-type burners, and operate at temperatures as high as 2500 deg. F.

The tubes are said to have 10-12 times the conductivity of fire-clay refractory and to be fully comparable to conventional alloy tubes with respect to heat radiation. In the furnace, the tubes are positioned horizontally so that any tube or combination of tubes can be shut off as required, thus assuring close control of temperature uniformity throughout all parts of the sheet pack.

Portable Brinell Hardness Tester

A portable hydraulic instrument known as the Knerr-King hardness tester that makes the standard Brinell test with a gradually applied load of 500, 1,000 or 3,000 kg. on a 10-mm. ball, is being introduced by Andrew King, 521 Broad Acres Road, Narberth, Pa. This instrument will do any testing that can be done on a stationary Brinell machine, it is claimed. The complete instrument weighs less than 26 lbs., can be conveniently taken to work that would be difficult to transport to a stationary type of hardness testing machine, and operated in any position, even upside down. Bars, rails, castings, tubes, and forgings can be tested in place.



Reciprocating Hardening Machine

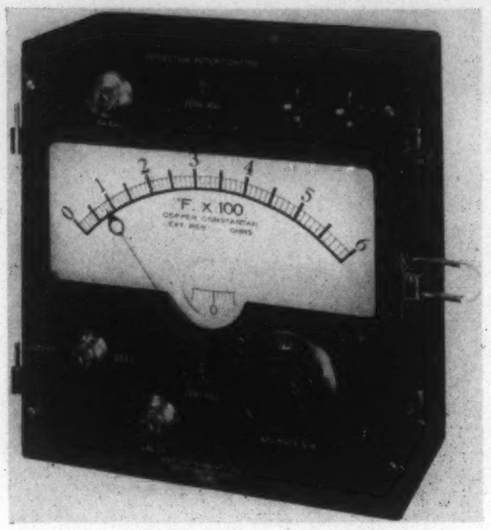
A new, larger size (No. 191) reciprocating full-muffle clean-hardening machine, manufactured by American Gas Furnace Co., Elizabeth, N. J., has a capacity of 400-600 lbs. of work hardened per hr. The available heating space is 18 in. wide by 9 ft. long.

The work may be practically anything, it is said, from extremely small light springs, stampings, drop forgings, etc, up to very large and heavy pieces. Since all mechanism is outside of the furnace proper, conveyor troubles are said to be eliminated. With the reciprocating muffles always in the heating chamber, efficiency is improved.

Because of the various means available for regulating the operating factors, the time-temperature cycle can be adjusted to meet any requirements. Suitably designed seals permit the use of any desired atmosphere in the muffle, ranging from slightly oxidizing to highly reducing. Special design features can be incorporated at the user's request to accommodate unusual-shaped pieces or special atmospheres.

Portable Potentiometer Pyrometer

A new type of portable potentiometer pyrometer for the measurement of temperatures by thermocouple is announced by J-B-T Instruments, Inc., 441 Chapel St., New Haven, Conn. The instrument, model 70-PO (illustrated), is said to require less balancing and less effort to operate than previous potentiometers. It is unusually light in weight, less than 5¼ lbs., and uses no standard cell, only a flashlight cell being required.



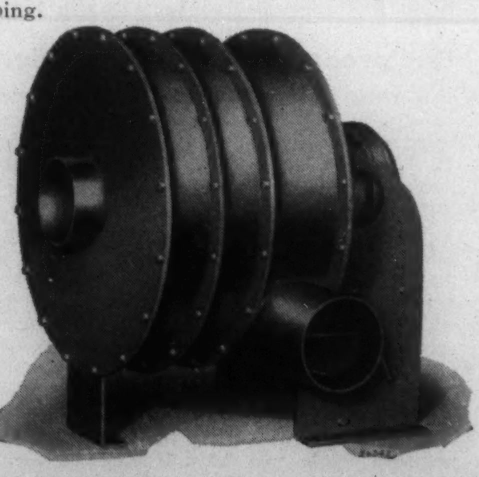
Readings of temperatures that are varying rapidly, accuracy of ½-1 per cent of total scale deflection, the sensitive but rugged double-pivoted Triplett galvanometer, and automatic cold junction compensation inside the case are among the advantages claimed for the new instrument. In addition, it provides a scale drawn to the customers' requirements in each case. Small thermostats can be used where other temperature-sensitive elements would be too slow, too large or too fragile, and the thermostats can be readily removed and replaced when necessary.

The greatest advantage is said to be less balancing. With scales of 0-400 deg. F. and higher, the new instrument requires no further balancing operation once it has been balanced and adjusted, but is thereafter read as a deflection instrument. On scales below this range, one balancing operation is needed for each temperature reading. The instrument lists at $120.00 single scale, $145.00 double scale.

Combustion-Air Blower

A new "Motorblower" featuring reliability, quiet operation and low cost has just been announced by Ingersoll-Rand Co., 11 Broadway, New York.

The new Motorblower (Type G) is said to be ideally suited for furnishing air to oil- and gas-fired furnaces. It can be installed on any floor without special foundation. A built-in blast gate is located in the blower discharge, and flexible pipe connections are provided for connecting either intake or discharge to shop piping.



Maintenance of constant pressure over the entire volume range permits direct connection to several burners, any one or more of which can be turned off without affecting the others. The 72 sizes of Type G Motorblowers available provide pressures from ½ to 2¼ lbs., and volumes from 100 to 4,500 cu. ft. per min.

Quick-Heat Soldering Iron

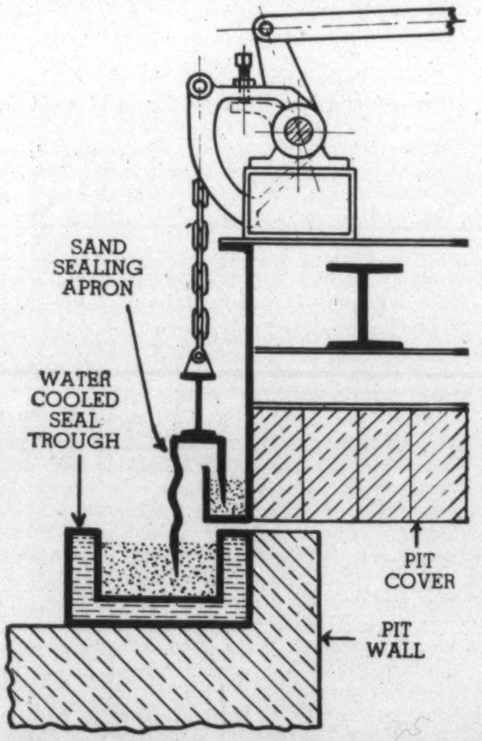
Soldering heat in less than a minute is the claim for a new soldering iron just announced by Ideal Commutator Dresser Co., 1928 Park Ave., Sycamore, Ill. Through the use of a special carbon electrode heating element, an entirely new principle in electric soldering iron design, the tip is quickly brought up to soldering temperature, and heat is concentrated where it is most effective.

Heating is controlled by a thumb-operated button on the handle and continues as long as the button is held down. The new iron is recommended for all ordinary soldering purposes as it is small and light in weight for easy manipulation. It is not recommended for continuous duty. The complete assembly includes transformer, soldering iron and leads, and shipping weight is 9 lbs.

Soaking Pit Cover

Better control of ingot heating and greater economy in soaking pit operation are objectives of a new pit cover developed by Blaw-Knox Co., Pittsburgh, Pa. The unique feature of this cover is a new way of obtaining a gas tight seal (patented). A suspended movable apron or sealing curtain around the periphery of the cover effects the seal by engaging two sand troughs. Instead of lifting or lowering the entire cover to make or break the sand seal, only the curtain is moved.

The mechanism for sealing is relatively light in weight; the curtain itself weighs less than 1,000 lbs. The parts of the curtain subjected to radiant heat when the cover is open, and certain parts of the dry seal trough, are made of alloy material. The essential novelty of the pit cover is that the movement for sealing is divorced from the movement of the cover. The cover is like a movable roof that rolls smoothly, without shock or jar, to cover or uncover the pit.



The cover can be designed for the use of either suspended or crowned arch brick, although the former is best for most conditions. Blaw-Knox Co. has built two of these covers for an Eastern steel plant and very satisfactory service is reported from them. The seal curtain is illustrated in the accompanying diagram.

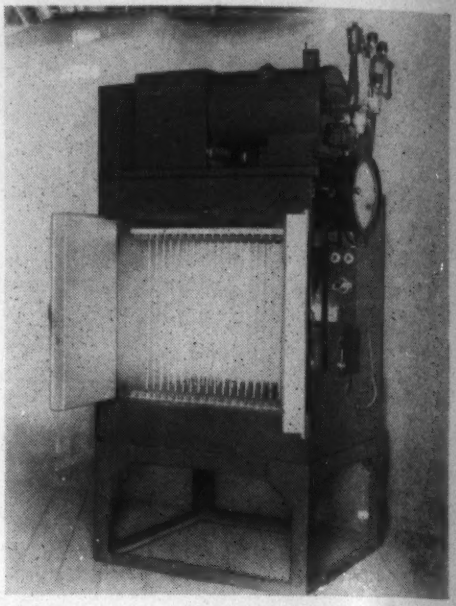
Filters for Electroplating

Claimed to be an entirely new approach to the problem of keeping plating solutions clean, the new "Hy-Speed" plating filters of Alsop Engineering Corp., Milldale, Conn., incorporates filter discs built up of many layers of the finest filter materials.

The new filters are described as capable of handling as large a volume of solution as conventional filters 10 times their size. This implies less space occupied, less maintenance and operating costs, easier handling, etc. In addition, the Hy-Speed filters are claimed to set new standards of thoroughness by offering ultra-fine filtration and, therefore, highly superior clarification of solution.

Tempering and Drawing Furnace

This new furnace is claimed very economical in operation. The heavily insulated walls retain the heat on the inside where it is required, the increased efficiency of the Despatch external heater with controlled combustion assures more heat getting into the furnace from the gas being burned and the use of recirculation are all factors that make operating costs very light.

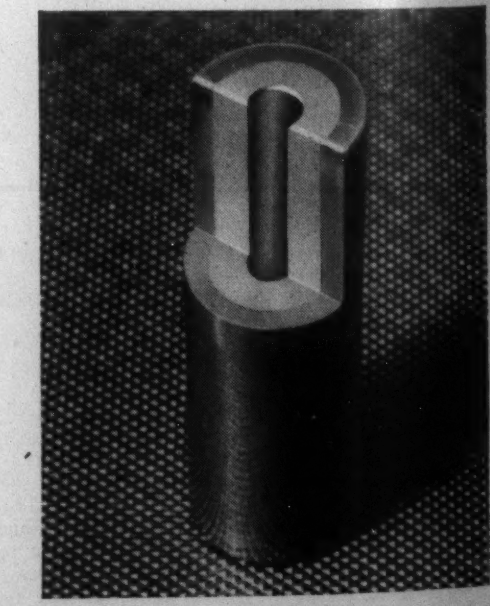


The Despatch furnace, shown in the illustration, is provided with side seeing doors with special heat seal arrangement and the doors are equipped with Despatch compression type latches which are fully approved by fire underwriters. If lift doors are desired, these may also be provided on this type of furnace. The furnace is fully equipped with recording temperature control system and full safety arrangement.

Any additional information concerning this line of furnaces will be gladly furnished upon request to the Despatch Oven Co., Minneapolis, Minn.

Work Rests

Work rests for supporting work in machine tools and other metal working machinery are now supplied with Kennametal inserts by the McKenna Metals Co., 158 Lloyd Ave., Latrobe, Pa. Because of the unusual hardness of Kennametal (76 to 78 Rockwell "C"), work supports in which this material is used are claimed to have long life and to assure accurate positioning of work.



Kennametal work supports are made to specification in any practical length, diameter and bore. The illustration shows a cut out view of a typical work support used to support a pinion in an automatic screw machine. In this instance, the work support is 1½ in. long with ½ in. outer diameter.

(Continued on page MA 306)

ITH.
FOXBORO
REG. U. S. PAT. OFF.
Instrumentation
Certified Accuracy and Response
TEMPERATURE • LIQUID LEVEL
PRESSURE • FLOW • HUMIDITY

"WELL, J. C., THE INSPECTOR'S JUST FINISHED CHECKING THE LOT AND THERE'S ONLY 3 DUDS IN THE ENTIRE RUN. THAT'S JUST ABOUT AN 80% DROP IN REJECTS SINCE WE STARTED UP THE NEW **FOXBORO** PYROMETER CONTROLLER!"

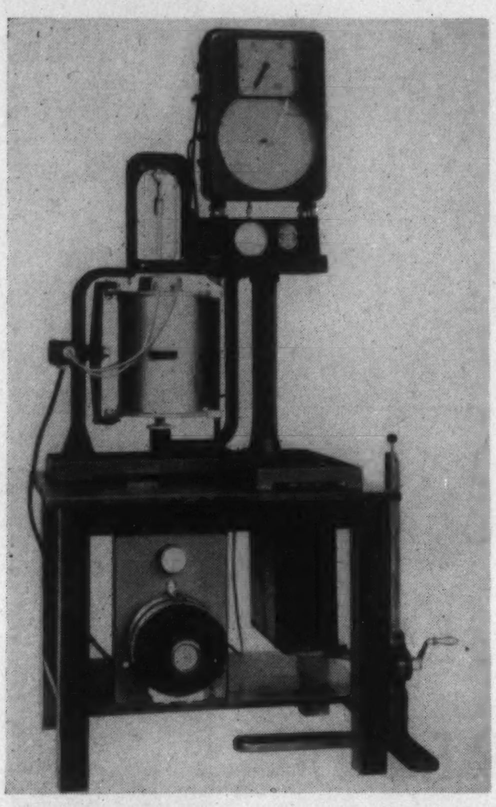
Get an earful from one of the foremen any place where Foxboro instruments are at work and the chances are you'll hear something that adds up to the same thing: *Because Foxboro has the edge in practical performance, Foxboro gets the vote of the men in the plant.*

THE FOXBORO CO., 54 NEPONSET AVE., FOXBORO, MASS., U.S.A. • BRANCHES IN 25 PRINCIPAL CITIES

New Dilatometer

A new dilatometer, designed by Stanley P. Rockwell of Hartford, Conn., is now available through The Bristol Co., Waterbury, Conn.

The "Rockwell-Bristol Dilatometer, Model RB," is a direct reading dilatometer which both indicates and makes an ink record of time-dilation and temperature-dilation changes simultaneously, during heating and cooling cycles of ferrous and non-ferrous metals, ceramics and many other materials of rigid form.



Temperatures are recorded on a Bristol's Pyromaster potentiometer, 12-in. round chart and the time element is recorded by a separate pen through a telechron clock. Further information may be obtained from Bulletin No. 546.

Hopper-Type Barrel Plating

A new hopper-type barrel plating machine, made at the Chrysler-Plymouth plant in Detroit by Hanson-Van Winkle-Munning Co., Matawan, N. J., has been in operation for a sufficient length of time to give interesting operating data on this type of equipment.

A large variety of small parts, very difficult to clean by ordinary dipping methods, are run through a cleaning cycle from hopper to hopper and finally plated in the same system. Each hopper requires about 55 sec. for a complete cycle. Production, assuming continuous load, is one hopper load into the dryer every 110 sec. Plating cylinders take from 75 to 200 lbs. at a time, depending on size and shape of parts.

At the present time, 7 men are required in this plating line, and it is estimated that with a slight change this force can be reduced to 5 and still maintain the present production from this equipment of 3,000-4,000 lbs. per hr.

Corrosion Resistant Rubber Putty

Metallurgical engineers working with such operations as pickling, cleaning, electroplating, electrorefining, chemical treatment of metals, processing of chemicals, etc., will be interested in "Plastikon," a rubber putty manufactured by B. F. Goodrich Co., Akron, Ohio.

This material is said to have many applications where fumes or gases that destroy the properties of ordinary putty are present. Plasticity is retained for long periods. Plastikon rubber putty is claimed to produce and maintain the air-tight and water-tight seals that are often essential. It adheres strongly to wood, steel and glass despite weathering, vibration or the presence of corrosive chemicals and fumes.

Six thousand pounds of Plastikon has been successfully applied in the electrolytic tank house of the Phelps Dodge copper refinery at El Paso, it is reported. The rubber putty has retained its softness and elasticity so completely that eventually it will be applied to all steel sash in this tank house.

New Ladle Graphitizer for Cast Iron

The development of "SMZ" alloy, a new graphitizing material containing silicon, manganese and zirconium, has been announced by the Electro Metallurgical Co., unit of Union Carbide & Carbon Corp., 60 E. 42nd St., New York, for ladle addition to cast iron. Its use is said to be effective in

(1) converting a normally hard white iron to a high strength gray iron

(2) reducing the sensitivity to chilling of thin sections of gray iron

(3) improving the microstructure and, therefore, the strength and other properties of the iron.

Wedge-shaped chill block tests on a base iron containing approximately 2.30 per cent carbon, 1.0 silicon and 0.30 manganese melted in a commercial air furnace show that this iron was transformed from an ordinary hard white iron to an iron that was completely gray, except near the chilled edge, by treating in the ladle with enough SMZ alloy to raise the final silicon percentage of 1.60. The SMZ alloy is said to be equally effective in reducing the chill of gray iron and in preventing the chilling of thin sections of this materal.

The action of SMZ alloy is said to be due not to its silicon content alone but to the ladle addition of a balanced combination of elements. Similarly, the beneficial action is claimed to extend much beyond simple graphitization. For example, a series of base irons having progressively lower silicon contents was treated with progressively increased additions of SMZ alloy to give essentially constant final silicon analyses. Tests on the physical properties of these irons showed a progressive improvement in mechanical properties as the amount of SMZ alloy added was increased.

In another instance, a cast iron converted from white to gray by the addition of SMZ alloy was reported to have 51,700-lb. per sq. in. tensile strength, 3,800 lbs. transverse strength, 0.415 in. deflection and 207 Brinell. The base iron contained 2.66 per cent total carbon, 1.15 silicon and 0.36 manganese, and the amount of SMZ alloy added was sufficient to increase the silicon to 1.65 per cent.

Portable Pyrometer Potentiometer

A portable pyrometer potentiometer has been developed by the Lewis Engineering Co., Naugatuck, Conn. It is claimed to be unaffected by vibration and suitable for use in moving vehicles and airplanes. Instrument is said to be accurate regardless of surrounding temperatures between minus 60 and plus 115 deg. F. Features include: One balancing operation; no standard cell; no suspension galvanometer, single or double range scales; low-resistance double-pivot galvanometer, and cold junction inside instrument. Instrument is compensated and measures atmospheric temperatures with thermocouples. Its dimensions, 6¼ x 9¼ x 10¼ in., has 8-in. scale and weighs 13 lbs. Model 13PO single range (standard) costs $175 net.

Carbide-Tipped Gages

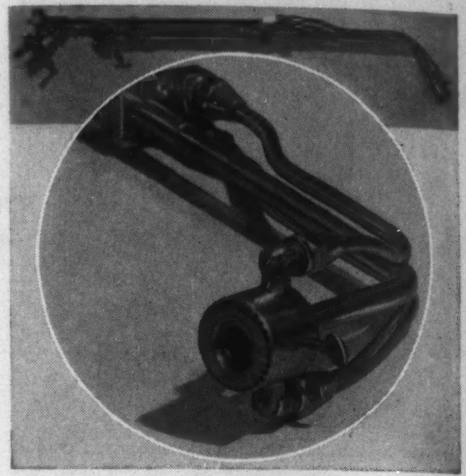
Go and no-go gages tipped with "Kennametal" (Tungsten-titanium carbide) are now available for the accurate gaging of cylinders, tubing, and other parts where the dimensions must be held to a close tolerance.

As shown in the illustration, the new go and no-go gages consist of notched steel blanks with small pieces of Kennametal brazed at both ends where the work is measured. Gages can be made to measure any practical tolerance in almost any diameter. Kennametal is said to be useful on other types of gages and instruments, because of its wear-resistance and non-rusting quality. Complete information on Kennametal-tipped gages and micrometers will be furnished by McKenna Metals Co., 158 Lloyd Ave., Latrobe, Pa., on request.

Torches for Flame Treating

The welding torch possesses a versatility far beyond its generally accredited utility for welding, brazing, soldering, hard-surfacing and heating.

Three torches manufactured by the Victor Equipment Co., 844 Folsom St., San Francisco, are examples of the virtually unlimited scope of torch flame application. One was specially designed to flame harden the surfaces of rock plant screening plates. A wide roller facilitates the torch operation and prevents tilting of the nozzle as it passes over the series of holes in the plate. Another, a large, circular, multiple-flame heating nozzle, was designed primarily to take out buckles in plates by heating them. This torch (illustrated above) has a water-cooled tip and can be provided with integral quenching head.



Flame descaling and dehydrating, while by no means new, are being used more and more to remove rust or occluded moisture from structural steel surfaces prior to painting them. A nozzle for this purpose comprises removable sections, permitting the width of the ribbon of flames to be adjusted to meet specific requirements.

Electropolished Stainless Steel Castings

The Cooper Alloy Foundry Co., Elizabeth, N. J., manufacturers of stainless steel castings, valves, fittings, etc., now offers its products finished by a new, patented electrolytic process known as "Lustracast." The process is not a surface coating but an electrolytic bath that is said to not only clean and brighten plain and ornate surfaces but to provide smoother surfaces, affording less chance for surface contamination and contact corrosion. The process also improves machinability owing to a more uniform removal of scale, and "salt spray" tests are claimed to indicate a considerable advantage over sandblasting and pickling methods in corrosion resistance.

The particular advantages claimed for the new process over existing methods are that (1) it gives a high, lustrous sheen comparable to the finest mechanical polishes, but at a much lower polishing cost; (2) that it cleans and brightens odd-size, odd-shaped castings formerly impractical or impossible to polish; and (3) that it assures longer life by greater resistance to corroding liquids.

Wider applications for its use are claimed, such as architectural and ornamental castings, castings handling food products and castings with surfaces impossible to reach by the conventional polishing or burnishing methods. This is further enhanced by the marked degree of passivation obtained. An illustrated descriptive folder on "Lustracast" may be had on application to the company.

Photocell Detects Flaws in Strip

Westinghouse Electric & Mfg. Co. reports the successful use of a photoelectric hole detector for spotting holes as small as 0.01 in. in steel sheet moving as fast as 1,000 ft. per min. in a shearing line.

Strip edges are trimmed before entering the hole detector between guides. Two light sources are mounted overhead with the phototube housing below the moving metal sheet. The slightest hole in the strip lets light pass through to actuate the photocell and a marking device scores the strip alongside the flaw.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

A Digest of Important Developments in the World of Metals

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1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

5. General

Articles pertinent to more than one of the previous sections.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

Superheating of Melts

Nucleus Formation in Metallic Melts ("Ueber die Keimbildung in Metallschmelzen") L. Horn & G. Masing. *Z. Elektrochem.*, Vol. 46, Mar. 1940, pp. 109-119. Original research.

The curve of numbers of crystals per degree temperature drop for antimony shows a considerable influence of superheating on undercooling. While the maximum of the curve for 38° F. superheating occurs at 18° F. undercooling, the maximum for 76° superheating occurs at 115° F. undercooling. The significance of this is that superheating renders nucleus formation more difficult.

The effect of superheating is not lasting. If a melt previously superheated about 90° F. is superheated after solidification for only 36° F., the amount of undercooling in the new crystallization is determined by the last superheating. The reason for this behavior is assumed to be very small non-metallic impurities whose solubility in the melt increases with temperature. The time of heating to different temperatures has no influence on the result in antimony.

Investigations with aluminum yielded substantially the same results. The undercooling is less for aluminum; it increases with superheating, but much slower than for antimony. The limiting value for superheating —*i.e.*, the value above which the nucleation no longer decreases with increased superheating—seems to lie above superheating of 360° F. It is a known fact that superheating of an aluminum melt coarsens the structure of a chill-cast piece. There is proof now that this is due to the effect of superheating on the nucleus formation.

The microstructures of both metals show that when crystallization takes place at a higher temperature (after identical superheating and identical cooling rate) fewer crystals are formed. However, according to the curves even fewer nuclei were to be expected. This discrepancy is explained by postulating the existence of certain "convection currents" which break the newly formed delicate nucleus, with the formation of new nuclei. No appreciable or uniform influence of the cooling rate could be determined. RPS (1)

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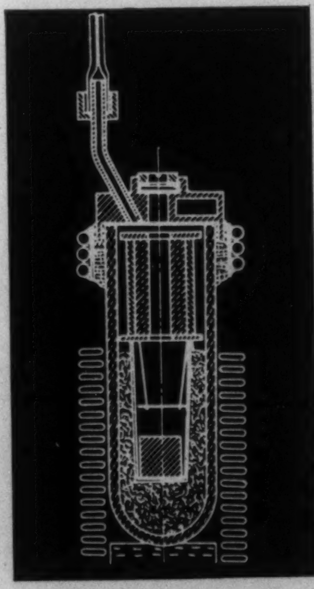
Tell us the kind of metal you pickle, the acid used, the acid concentration, and the temperature of the bath. We can then suggest the proper RODINE for your use.

Bulletin on request

AMERICAN CHEMICAL PAINT CO.

Dept. 307, AMBLER, PENNA.
DETROIT, MICH. WALKERVILLE, ONT.

THE SOLUBILITY OF NITROGEN IN MOLTEN IRON-SILICON ALLOYS



Furnace used in solubility experiments.

For instance: was determined by experiments made with a small Ajax-Northrup High Frequency Furnace (Technical paper No. 1109, AIME).

Rates of graphitization, formation of cementite, carbon content of pearlite, vacuum melting, powder metallurgy and rock fusion are other examples where precious laboratory time is saved and results otherwise impossible obtained.

Ajax bulletins T-5 and T-6 will give you suggestions for the profitable use of AJAX FURNACES in your laboratory and plant. Ask for them.

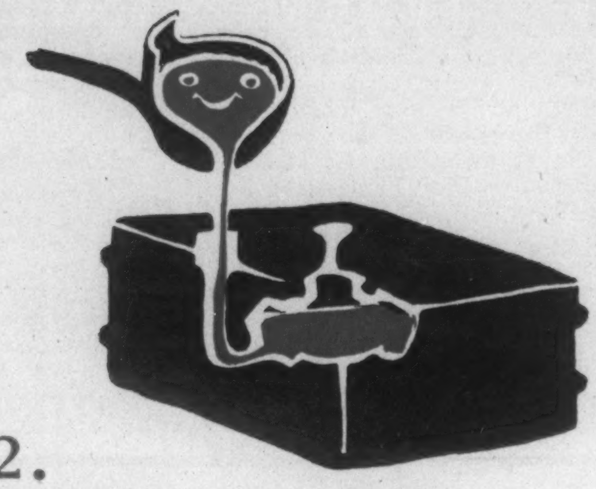
AJAX ELECTROTHERMIC CORPORATION
AJAX PARK
TRENTON, N. J.

AJ-23-D

Wonder What a Casting Thinks About?

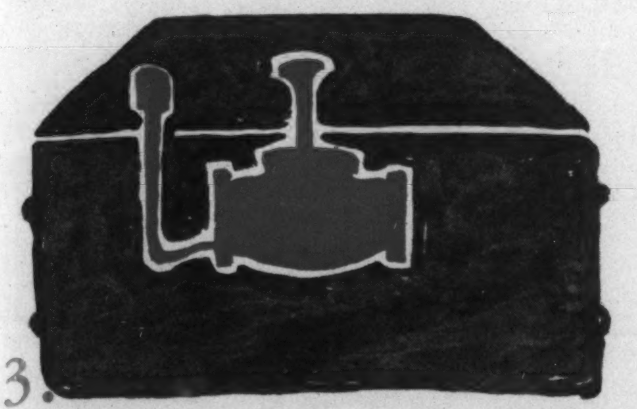
1.

"I'm red-hot metal rarin' to go. Hope the boss put that good, low-cost Truline Binder in the cores."



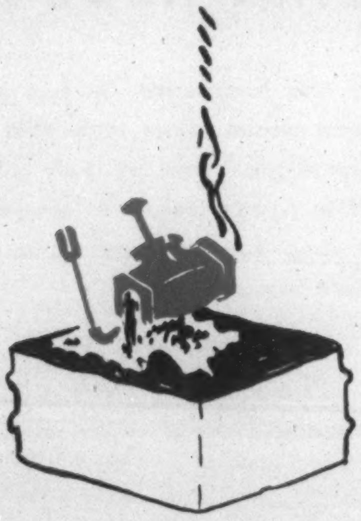
2.

"Yep; he did. I can tell by the way I lay to it without bouncing back. Another thing—that Truline core-wash makes a slick surface."



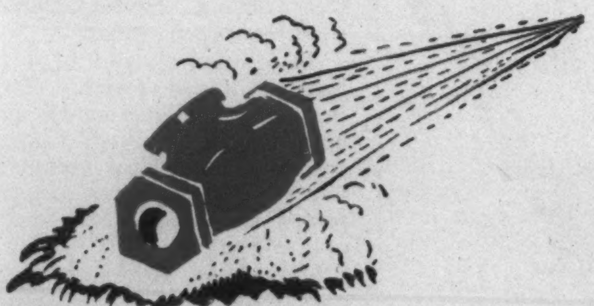
3.

"Ah! What a grand and glorious feeling. That Truline Binder burnt out at just the right time. See the core collapse as I shrink."



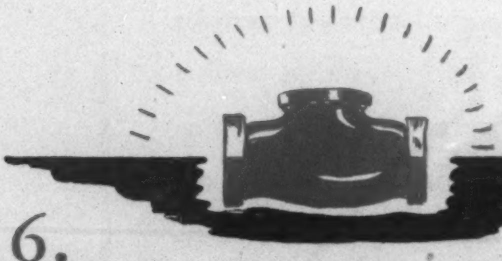
4.

"Now my boss is going to find out how smart he is. Wait till he sees the way the core has burnt out, and the swell surface that core-wash gave me."



5.

"And the stuff cleans off like nothing. They won't be rapping me this trip; and the boss'll save some jack."



6.

"Look me over. I'm sound as a dollar . . . clean and smooth . . . no cracks, no pits, no scabs. I sure have to hand it to Truline."

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CAN BE USED WHEREVER METALS ARE CAST

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There's a moral to this story. Hundreds of foundrymen . . . casting steel, gray iron, malleable iron, and non-ferrous metals . . . . are getting good castings and saving money with Truline Binder. You can, too. Why not write for a trial lot today?

1a. Ferrous

Blast Furnaces—Here and Abroad

A Composite

"We hear a lot in these troublesome times about manpower and aircraft power, but a good look at a country's blast furnaces and blast-furnace practice will tell something just as important about its ability to make a war—or to take one," says WM. A. HAVEN of Arthur G. McKee & Co. ("Foreign Iron Blast Furnace Practice," *Mining & Met.*, Vol. 21, Apr. 1940, pp. 182-187).

On this timely basis Haven appraises progress in blast furnace design and operation in several foreign countries, and compares foreign developments with American. The latter he describes in some detail in an article for British consumption ("The Manufacture of Pig Iron in America," *J. Iron & Steel Inst.*, Adv. Copy, May 1940, 43 pp.). Most American pig iron is made in the midwestern district, using very similar raw materials, which have determined blast furnace design and operation for the entire industry in this area.

Equipment for charging the very large tonnages of ore required per day (2500 tons per furnace), along with the necessary coke, limestone and other raw materials, with a single man per turn, is one of the outstanding accomplishments of American blast furnace design. For hoisting and top-charging, so-called hand-filling has practically disappeared; the double-skip automatic mechanical equipment is spreading in use. Application of skip-filling, however, would have been almost impossible without the development of distributing devices, like the McKee revolving top, on the furnaces.

The modern American furnace is the result of improvements introduced to ease the "growing pains" of the industry after 1890, when fine, soft Mesabi ore began to be widely used. Furnace shells were increased in thickness from ¼ in. to 1¼ in. The use of cast iron for hoppers and bells was discontinued in favor of steel. External sprays for cooling hearth and bosh gave way to cooling plates laid in the brickwork. Today's refractories are not only more durable, but remarkably accurate and more uniform as to size and shape of single bricks. For tonnage output, the linings on American stacks are unsurpassed, many runs reaching 1-2 million tons with a maximum of 2.5 million on a single lining.

American furnaces are characterized by large hearth and top diameters, great overall heights and low steep boshes. Twenty-five ft. hearth diameters and 100 ft. heights are standard for 1,000 ton-per-day output on Lake ores, with a recent tendency to still greater heights. J. P. DOVEL ("Excess Ash in Coke," *Steel*, Vol. 106, Feb. 19, 1940, pp. 70-71; "Hearth and Bosh Areas," *Ibid.*, Apr. 22, 1940, pp. 60, 64) advocates further enlarging of the top sections of smaller American furnaces to twice their original area, to give (when combined with increased stove and power plant capacity) greater tonnage, higher blast temperature and greater carbon efficiency. Although records show an increase in blast furnace efficiency of 16% and a reduction in coke consumption of 400 lbs./ton of iron to be thus provided, only 8 American furnaces have been so modified.

Haven lists many important American improvements in auxiliary equipment. Skimming trough and iron- and slag-runners are now made in permanent heavy iron castings. The trough is generally lined with fireclay and the runners with sand and coke breeze mixtures. Mud guns capable of stopping tapping with full blast pressure on are considered essential. Mixer-type ladles up to 125 tons capacity have proved economical. The procedure of machine casting of pigs has been perfected. For slag-handling, self-dumping ladles up to 400 ft.^{3} capacity are universally used. Power plants reflect the adoption of improved steam-raising, electro-generating and air-compressing machinery.

Thoroughly-cleaned blast furnace gas is now considered essential. Two methods are in common use—Cottrell precipitators as built by the Research Corp., and disintegrators of the usual types. The precipitators are higher in first cost, but have lower power consumption and total cost per unit of gas handled.

Since 1933, American methods have become more uniform. All new furnaces have been of the 1,000 ton class and the rebuilding of old stacks to larger sizes continues, with consequent increased output per stock and cost reductions, as well as better results metallurgically. Coke consumption rates are lower, dust losses have been curtailed and pig iron quality has been improved.

Furnaces of generous diameter and volume have been successful in other American districts and other countries where the iron ores have differed greatly from the fine Lake Superior type—with richer and coarser ores as in Russia and India, and with leaner and coarser ores as in the American Southern area.

Discussing these foreign methods, Haven points out that the advanced stage of the art in America has been recognized abroad and when new plants are built abroad, American-type plants have been installed—in India, Austria, Russia, China, and to a

[*Continued on Page 316*]

SPECIAL ALLOYS for EXPERIMENTAL WORK

• Metal Hydrides Incorporated is in a position to produce special alloys of a wide variety of compositions. Most of these alloys are furnished in powder form. At somewhat higher price they can be supplied in the form of sintered ingots.

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• The composition may be varied in wide limits yet certain alloys are recommended with a definite percentage of the alloying element, such as uranium-nickel with 66% of uranium, since this composition has outstanding characteristics. The melting point of this alloy is lower than that of copper.

- **Beryllium-Nickel**
- **Cobalt-Chromium**
- **Nickel-Chromium**
  to
- **Copper-Zirconium**
- **Titanium-Nickel**
- **Uranium-Nickel**
- **Thorium-Nickel**

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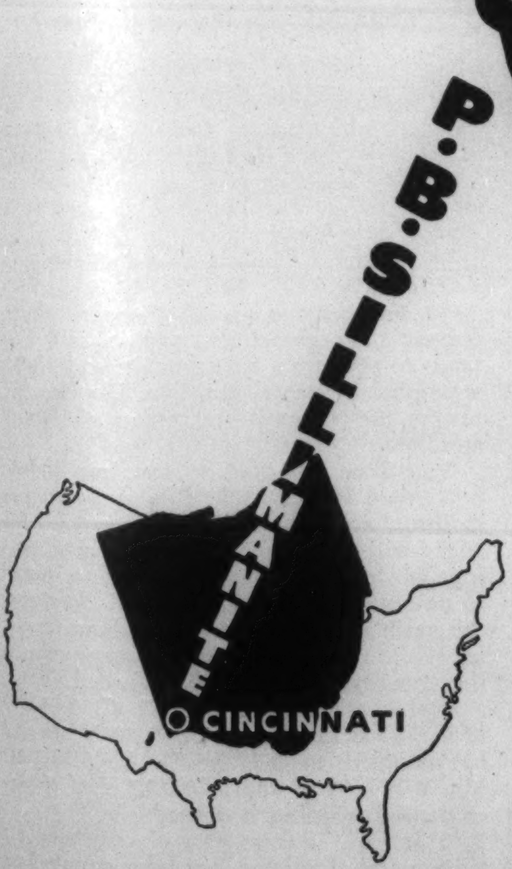

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lesser extent in Great Britain. In Italy, Japan and the Near East the plants have been almost entirely of German design, which until recent years differed from ours in many important respects.

In 1932, with the exception of gas-cleaning, German plants and methods were inferior to American—probably because they were obliged to use a hodge-podge of ores, from hard Swedish magnetites to soft North African hematites. Often, too, the blast furnace is regarded not as a producer of a finished product, but as a *concentrator*, with practically all refinement left to the steelmaker.

As to equipment, the German plants seemed clumsy, complicated and costly to build. Yet, one could find the ultimate in refinement—a coke-screening station installed on top of the furnace. Today, the Germans still apply clean gas more than we, but it is doubtful that our precipitator-type cleaning equipment can be surpassed. Even Germans now admit that the American blast-furnace plant is on the whole better, and many German furnaces built in the last decade are obviously copies of American plants, with one vast new plant (reported to comprise 32 furnaces) designed by Americans.

Germany, through great organizing ability and with the aid of American designs and equipment, will remain in a dominating position in iron and steel production. Only continued control by others of iron ore supplies can limit the degree of her supremacy in Europe, and this limitation she is struggling to overcome by taking into the Reich other states with ore reserves or extending her political influence over them, and also by a powerful effort to utilize her own low-grade ore reserves.

Next to the U.S.A., Russia probably has the greatest number of large, modern stacks, although crudely and inefficiently operated. New furnaces are almost exclusively based on American design.

In Great Britain—fourth in world pig iron production—many furnaces have been built and rebuilt along modern lines, and lean domestic ores are being utilized to a greater extent and more economically. One new plant has the first complete beneficiation system of its kind, with facilities for crushing, sizing, blending and sintering. Great Britain may be expected to continue, with more modern equipment and methods, making up the ground she has lost to others.

All Canadian furnaces are of American design, and 2 of the 3 large plants use Lake ores and American coal. In India, the ores are among the purest hematites in the world, averaging over 60% Fe, and being also very coarse, are conducive to large furnace outputs. Stacks for the Indian Iron and Steel Co. were found to have about double the capacity they would have had with Lake ores. Two novel features of Indian practice are the high alumina content, yet clean, free-running nature, of the slag, and the high ash content of the coke.

New Italian stacks will be as nearly American in design as it is possible to get from their German builders. Most of the French furnaces are small, with bucket filling, independently-supported tops, banded stacks and bosh tuyeres as well as hearth tuyeres. Slow blowing is strikingly successful in reducing the total cost with 30% Fe ores. Not much progress has been made since the World War in modernizing French blast furnaces or blast-furnace practice. X (1a)

Vanadium in Iron and Steel

A Composite

Vanadium additions to cast iron, steel castings and wrought steels have been the subject of much recently published material. For example, a good review of the properties of vanadium-bearing cast irons and cast steels is given by F. STADLER ("Vanadin in Gusseisen und Stahlguss," *Giesserei*, Vol. 27, Feb. 23, 1940, pp. 57-59). Vanadium is a much stronger carbide-former than chromium, and in cast iron tends to produce a finer graphite and higher strength. In steels, vanadium likewise improves the strength and refines the grain structure.

Vanadium additions to cast iron should be limited to 0.2-0.3% V to avoid serious chilling, with unmachinable areas at the edges and corners. Vanadium-bearing castings are highly wear resistant and are stated to be heat-resistant up to 900° F. In steels, the grain refining effect of vanadium results in shallow-hardening, to overcome which the composition should be adjusted. Thus, a steel containing 0.30-0.38% C, 0.75-1.0 Mn, 0.25-0.50 Si and 0.15-0.20 V should be modified to 0.28-0.30% C, 1.20-1.80 Mn, 0.25-0.50 Si and 0.08-0.12 V, if greater depth-hardening is desired.

["Grainal," a ferro-alloy of vanadium, titanium and aluminum, has been reported to be highly successful in this country for producing steels that are simultaneously fine-grained and deep-hardening. Very small amounts are said to be sufficient, and, in addition, to give strength values equivalent to those of more highly-alloyed steels. See Strauss' feature article in this issue.]

Vanadium additions to cast iron and steel are ordinarily made by treatment with ferrovanadium containing 40, 60 or 80% V.

In America's largest Stainless Steel Mill

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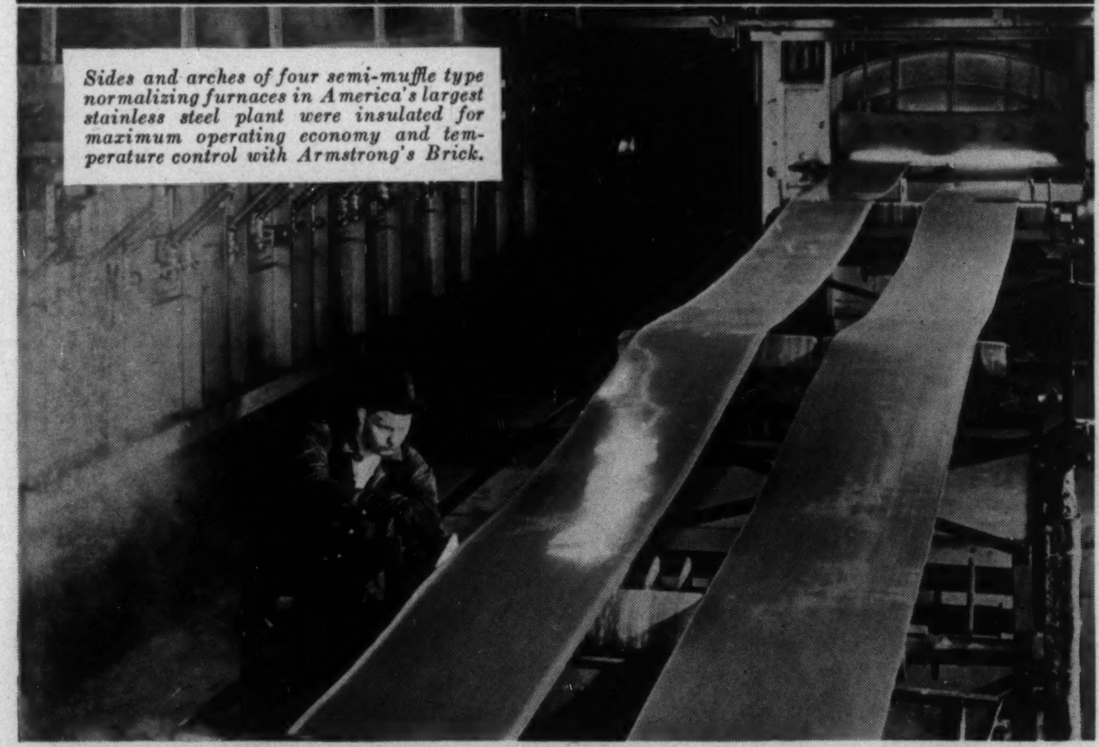

Sides and arches of four semi-muffle type normalizing furnaces in America's largest stainless steel plant were insulated for maximum operating economy and temperature control with Armstrong's Brick.

YEARS of satisfactory performance in the field, and extensive laboratory tests have proved that Armstrong's Insulating Fire Brick offer the kind of protection modern furnaces require. There's further proof of their wide acceptance in the use of these brick in four normalizing furnaces of America's largest mill for cold rolling and finishing stainless steel.

You can depend on Armstrong's Brick for accurate control of furnace temperatures, lower fuel costs, and greater efficiency—in almost any type of furnace design. There are five individual Armstrong's Brick available to meet varying temperature and service requirements. For literature, write to Armstrong Cork Company, Building Materials Division, 982 Concord Street, Lancaster, Pennsylvania.

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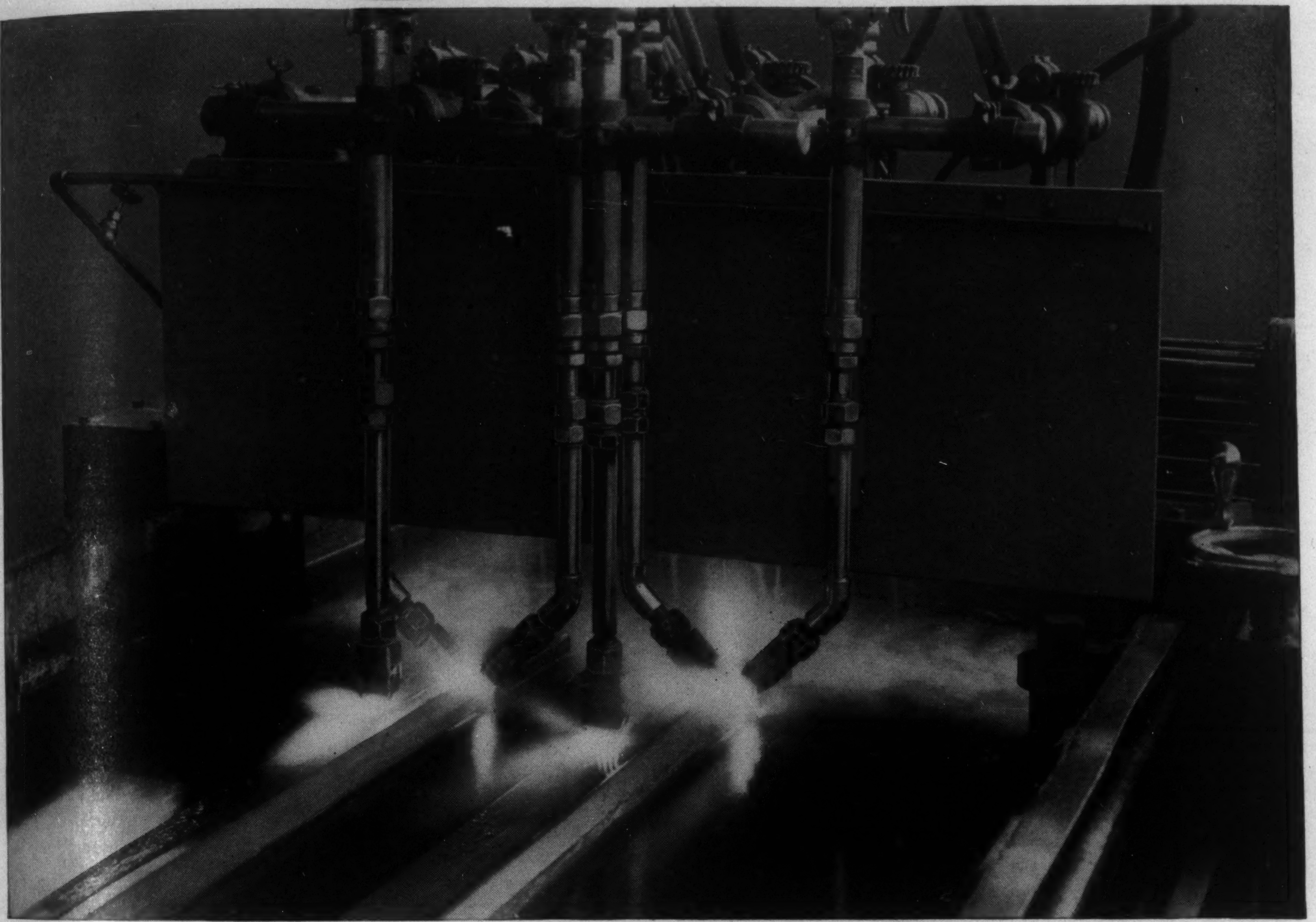

Airco Oxyacetylene Flame Hardening this cast lathe bed enabled the Monarch Machine Tool Company, Sidney, Ohio, to solve the problem of bed wear permanently. As a result, Monarch Lathes now last longer; need fewer repairs.

The grain structure of the entire flame hardened area is greatly refined and condensed. This is accomplished without materially affecting the physical properties of the core metal. Thus, flame hardened castings retain their original toughness and have the added quality of providing surfaces capable of withstanding severe wear. » » » The facilities of Airco's Applied Engineering Department are available to assist Airco customers solve problems involving surface wear. Write for full details.

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The specific effects of *ladle* additions of vanadium to cast iron are discussed by J. Wisser ("Die Einwirkung von Vanadin-Pfannenzusätzen auf Gusseisen," *Giesserei,* Vol. 27, Mar 8, 1940, pp. 81-83). Five different cupola-melted irons and one cupola-melted and superheated iron were treated in the ladle with powdered ferro-vanadium containing 60% V and 1.2% Si.

The most striking result was the much lower carbide-forming value of ladle additions of vanadium as compared with additions during melting. Thus, the graphitizing value of vanadium is generally placed between —2.4 and —3.6, but ladle-added vanadium seems to be about —1.0. Vanadium added in the ladle can replace nickel, nickel-chromium or molybdenum additions as strength improvers in cast iron, but is of no real help in providing heat-resistance. [Compare with Stadler's statement in the second paragraph, above.] Vanadium as a refining element for cast iron would be much more widely used in Germany if it were not so expensive in that country.

Vanadium has often been cited as a possible potent restrainer of intergranular corrosion caused by carbide precipitation in austenitic chromium-nickel steels. Tests to check this for steels with 18% Cr and 9-14% Ni were made by G. Riedrich & G. Koch ("Wirkung von Vanadin auf den Kornzerfall austenitischer Chrom-Nickel-Stähle," *Stahl u. Eisen,* Vol. 60, Jan. 11, 1940, pp. 30-31), using vanadium additions of 0.76-3.01%. The steels were air-cooled from 1900° F. and then reheated for 1 hr. at 900°-1300° F.

The most damaging grain boundary precipitation occurred at about 1100° F., and this even in the steels with the highest vanadium content. It was concluded that vanadium does not form a stabilizing carbide even when 25 times as much vanadium as carbon is present. The slight benefit noted because of the presence of vanadium in diminishing grain boundary carbide precipitation was attributed to the influence of vanadium in increasing the amount of ferrite.

X (1a)

Blast Furnace Gas for Open Hearths

Experiments Regarding the Use of Blast Furnace Gas and Oxygen-Enriched Air in the Open Hearth ("Vorversuche zum Betrieb von Siemens-Martin-Oefen mit Gichtgasbeheizung unter Verwendung von sauerstoffreicher Luft") G. Bulle. *Stahl u. Eisen,* Vol. 60, Mar. 7, 1940, pp. 201-206. Original research.

A small 200-lb. experimental open hearth furnace arranged to burn blast furnace gas with oxygen-enriched air is described, and logs of melts made in this furnace are given. Hot blast furnace gas and cold oxygen, and likewise hot blast furnace gas and hot oxygen-air mixtures, were tried.

The tests indicated that even the preheated gases did not give complete combustion, and that cross-current combustion would probably be needed to get better results. To try leaner oxygen mixtures a larger furnace would be needed. It is suggested that in such larger scale tests blast furnace gas be used only in part and mixed with richer gases like coke-oven or producer gas.

SE (1a)

Centrifugally Cast Brake Drums

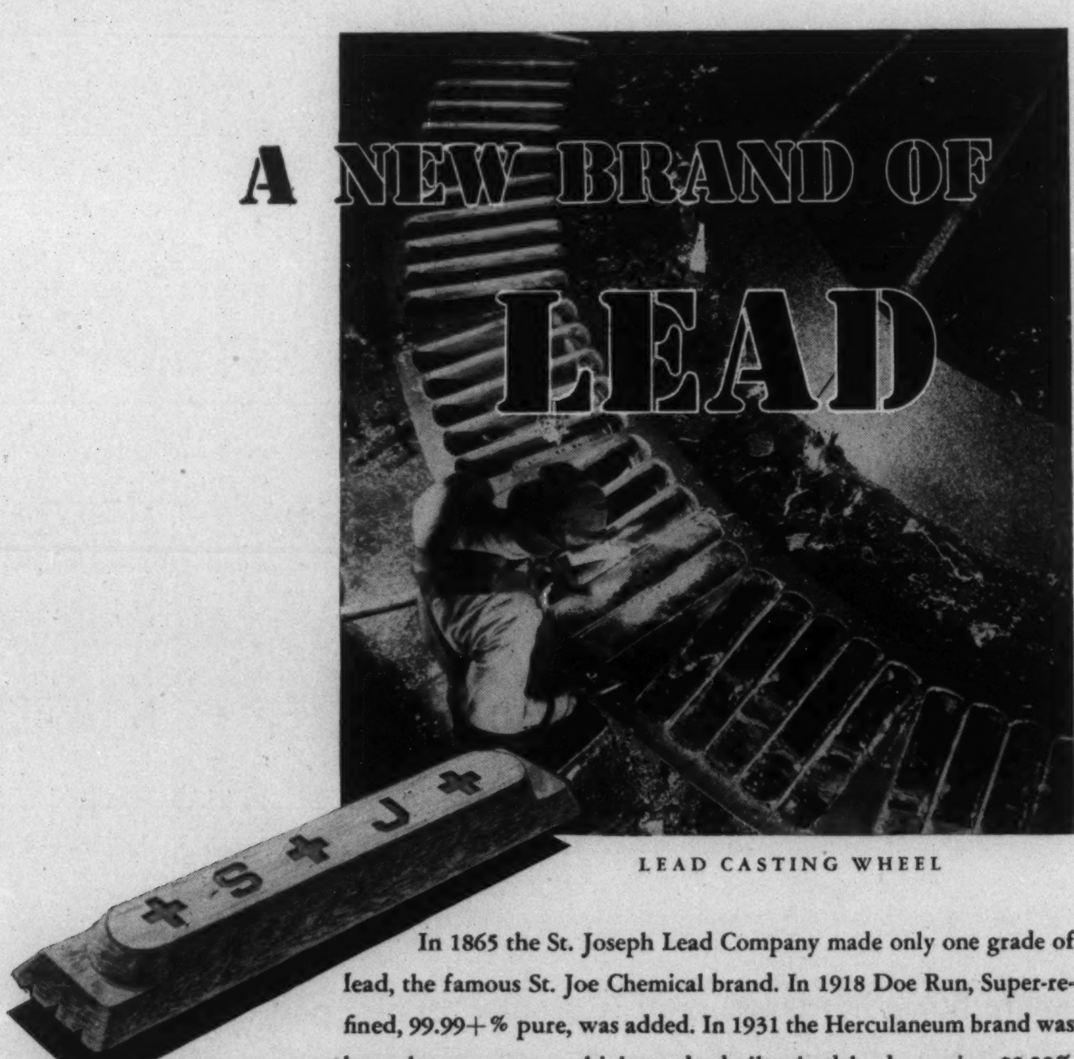
"Brake Drums Cast Centrifugally." H. H. Fairfield & Maurice G. Eldred (McKinnon Industries Ltd.) *Can. Metals & Met. Inds.,* Vol. 3, Feb. 1940, pp. 31-34. Descriptive.,

By casting in a permanent mold, it is possible to produce castings more uniform in size and balance than is possible by sand casting. Almost 90% of the iron poured goes into the finished product and less labor and less floor space are required. These and other factors favor the casting of automotive brake drums by the centrifugal process, fusing an iron ring onto a steel plate.

The cupola-melted iron is run into a mixing ladle or forehearth. The transfer ladle that takes the iron to the casting machine is of the insulated type with cover and teapot spout. Alloy and graphitizer additions are made as the iron is poured into the transfer ladle. A pouring ladle is filled from the transfer ladle and pouring is accomplished by swinging the ladle into position and rotating it at a uniform rate.

After solidification, the casting is automatically ejected, the weight checked and the ladle adjusted, if necessary. When the casting has cooled it is ground by 2 wheels simultaneously. A large wheel grinds a chamfer on the inside diameter to facilitate machining and a small wheel takes off the sharp corner on the outside of the flange.

The operations performed are, in order: (1) Inserting web plate and locking in position; (2) pouring iron into the rotating mold; (3) mold spins as iron sets; (4) casting is ejected from the mold; (5) the casting is weighed; (6) the ladle is cleaned and sprayed with graphite and water; and (7) the mold is sprayed with a clay mixture. Automatic pouring is under consideration. The main item in mechanical maintenance is replacing the molds and cover plates.



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*Quoted from an advertisement by Bridgeport Brass Company appearing in FORTUNE, July, 1939.

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To secure the greatest strength and the most wear-resistant properties in the high-carbon high-silicon iron base, ladle additions of copper or nickel with the usual graphitizer to the extent of 0.15-0.25% Ni or 0.20-0.30% Cu and about 0.25-0.35% Cr are made. Brake drum mold failures studied led to the development of an alloy which was cast centrifugally, possessed a very high mechanical strength and did not change its shape on repeated heating and cooling. This alloy was produced by adding 0.75% Cr, plus a graphitizing agent, to malleable iron. WHB (1a)

Balanced-Blast Cupola

"The Balanced Blast Cupola and Fluidity." Wm. Y. Buchanan. *Foundry Trade J.*, Vol. 62, Feb. 8, 1940, pp. 113-114; Feb. 15, 1940, pp. 133-134. Practical.

Some data concerning a balanced-blast cupola, 45 in. dia., and referred to as Lang No. 2, are given. The average tapping temperature is 2500° F. The lining, which was Glenboig firebrick, has done remarkably well (1280 days, through-put of 23,332 long tons). The lining still seems quite good after 5 yrs. operation. A typical melt consists of 5 charges of scrap and pig iron to be used for such castings as motor stools, 9 charges of borings and pig, and 4 charges of sand-plant and dressing-shop refuse. The oxidation loss, *i.e.* metal lost to the slag, was found to be 2.93%.

It is accepted by many foundrymen that the degree of fluidity is affected by the conditions of melting and the type of melting unit, and it was intended to ascertain what part the balanced-blast system played in the degree of fluidity. There is ample practical evidence of very high fluidity in metal from the balanced-blast cupolas on their early runs, as compared with the previous types that they replaced. The addition of scale to liquid cast iron in the quantity used, *i.e.* 6 ozs. scale to about 60 lbs. metal, seems to produce an exothermic reaction sufficient at least to counteract the cooling effect of the cold addition.

A series of fluidity tests were made with a spiral-horn gate mold, which was made by jolting. These showed that the balanced-blast cupola gives higher fluidity than the ordinary type. The Saeger and Krynitsky fluidity test, very useful when reasonable precautions are taken in its use, can be of service in maintaining good fluidity as an indirect but definite precaution against the common gas-holes.

Fluidity can be improved by ladle additions. Also, although the practice has not been completely studied, it seems that graphite addition improves the fluidity. Silicon has an adverse effect on fluidity, contrary to the general opinion of foundrymen. AIK (1a)

1b. Non-Ferrous

New Uses of Powdered Nickel

A Composite

Nowadays we instinctively think of powder metallurgy as a fabricating method—a way of making metal shapes of special structure or properties—all ready for incorporation in industry's products. In so doing, we forget that powder metallurgy encompasses many other fields than the making of compacts. Two of these that are of interest to the metal-production rather than the design engineer are described in recent German articles—one on the production of nickel sheet for cladding from sintered-nickel billets, and another on the use of nickel powder to make solid nickel-chromium alloys.

Nickel-clad steel is generally produced by welding together nickel and steel sheets under the pressure developed by hot rolling. According to L. Schlect & G. Trageser ("Die Verwendung von Carbonylnickel zur Herstellung plattierter Bleche," *Metallwirtschaft*, Vol. 19, Jan. 26, 1940, pp. 66-68), in Germany the sintering of nickel billets from nickel carbonyl has advanced to the stage where they are making nickel billets weighing 3,500 lbs. by this method.

Nickel carbonyl powder with 0.3-0.5% Mn is packed so as to weigh 3-3.8 gm./cc. in a steel mold and sintered at 1800°-2200° F. in a hydrogen atmosphere. Nickel with a density of 8-8.85 is produced by this process. Because of the large amount of shrinkage occurring during the sintering process, the relations of length, width and depth of the molds have to be carefully worked out to give best results. The sintering is carried out in vertical electrically heated furnaces with the direction of greatest shrinkage being vertical. The sintered nickel block is taken directly to a press and forged while still hot, and the forged slab is then hot rolled.

The commercially important nickel-chromium alloys are capable of direct production from chromium oxide and nickel, using hydrogen as a reducing agent, according to G. Grube & K. Ratsh ("Ueber die Darstellung von festen Chrom-Nickel-Legierungen durch Reduktion von Chromioxyd bei Gegenwart von Nickel," *Z. Elektrochem.*, Vol. 45, Nov. 1939, pp. 838-843).

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For sound non-ferrous castings . . . and for lower costs . . . you must have a reliable pyrometer . . . one that gives accurate readings yet one that will stand up under hard usage on the pouring floor and in the furnace room. The "Alnor" Pyro-Lance is the answer.

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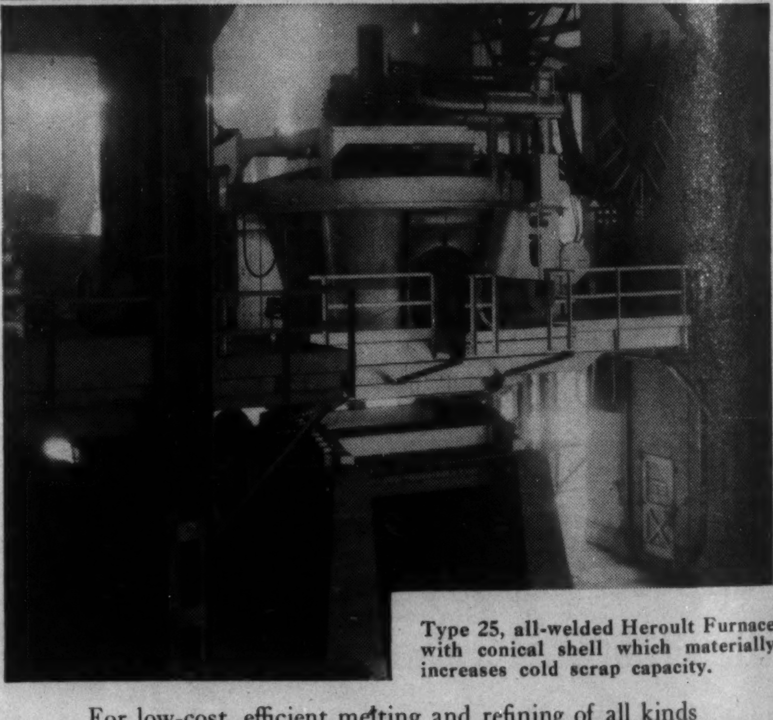

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. . . in figuring melting costs, do so many people fail to consider all of the 8 main factors?

1. Fuel costs
2. Labor charges
3. Crucible cost
4. Metal shrinkage
5. Per cent of castings rejected *before* machining
6. Castings rejected during and *after* machining
7. Upkeep
8. Interest and depreciation

Crucible Furnace Company
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It is a well-known fact that oxides that are difficult to reduce can be reduced more readily in the presence of nobler metals. In the solid state this is always to be expected if the two metals form a solid solution, as the forces of affinity aid in driving the oxygen from the less noble metal.

Hydrogen was purified by sulphuric acid, copper at 1300° F. (for oxygen removal), caustic potash (for carbon dioxide removal), calcium chloride and phosphorus pentoxide (for moisture removal). Carbonyl nickel powder was mixed with chromic oxide, pressed and heated to 2200° F. Alloys up to 30% Cr could be obtained. Subsequent experiments yielded alloys up to 80% Cr. A theoretical part of the investigation deals with reduction equilibria and determination of affinity in the formation of solid solutions. **X (1b)**

Segregation in Aluminum Alloys

INVERSE INGOT SEGREGATION WITH PARTICULAR REFERENCE TO COPPER-BEARING ALUMINUM ALLOYS ("Ueber die umgekehrte Blockseigerung, insbesondere bei kupferhaltigen Aluminiumlegierungen") PAUL BRENNER & WALTHER ROTH. *Z. Metallkunde,* Vol. 32, Jan. 1940, pp. 10-14. Review plus original research.

Among the five prevailing theories on the underlying causes of inverse ingot segregation, three are dismissed as obsolete. Regarding the remaining two possible causes, *i.e.* (1) pressure of gases released during solidification, and (2) forces set up by volume shrinkage, the first has been invalidated by demonstration that inverse ingot segregation occurs during solidification *in vacuo.*

This phenomenon becomes the more accentuated the greater the concentration difference between primary crystals and remaining liquid phase, and the larger the volume shrinkage during solidification. The local extension of the segregation depends on the width of the zone of solidification, which in turn depends on the temperature difference between liquidus and solidus, on the cooling speed of the ingot (the faster the heat dissipation, the smaller the solidification zone) and on the thermal conductivity of the solidifying alloy. It is possible to combat inverse ingot segregation by exceedingly rapid as well as by exceedingly slow solidification.

Experimental results on the distribution of inverse ingot segregation in commercial aluminum-copper-magnesium ingots solidified in different manners are presented. The uneven copper distribution horizontally and along the axis of a cylindrical, intentionally-piped ingot was particularly great. On the other hand, it was least in a long, small-diameter ingot that solidified slowly from the bottom to the top. In continuous pouring, the inverse ingot segregation was greatly suppressed in the case of a flat "shallow solidification front" obtained by properly directing the heat dissipation and solidification. EF (1b)

Refining Aluminum

THE REACTION CONDITIONS IN THE REFINING OF ALUMINUM MELTS WITH CRYOLITE AND SODIUM SILICOFLUORIDE ("Ueber die Reaktionsverhältnisse beim Raffinieren von Aluminiumschmelzen mit Kryolith und Natriumsilikofluorid") L. TRONSTAD & J. H. REIMERS. *Aluminium,* Vol. 21, Dec. 1939, pp. 834-838. Research.

The oxide films formed in remelting aluminum—either on the surface or as suspensions in the melt—must be thoroughly removed before pouring if a sound, dense corrosion-resistant product is desired. In small furnaces, nitrogen or chlorine may be blown through the melt, but in large scale melting the cleansing material may either be added to the solid charge or to the melt.

For additions to the charge cryolite (Na_3AlF_6) is particularly suitable, while for additions to the melt sodium silicofluoride (Na_2SiF_6) is preferable. Investigation of the system Al_2O_3—Na_3AlF_6 established that below the transformation point of the latter no Al_2O_3 is absorbed, but that beginning at 1200° F. the absorption starts and increases with rising temperature. Cooling down below the transformation point immediately precipitates the absorbed Al_2O_3 submicroscopically.

Examination of the system Al_2O_3—Na_2SiF_6 showed that the latter is decomposed by heating according to the reaction $Na_2SiF_6 \rightleftarrows 2NaF + SiF_4$. The sodium tetrafluoride formed melts at not lower than 1800° F. Chemical reactions between Al_2O_3 and Na_2AlF_6 take place only in the solid state; also, the necessary liquid phases for reactions with Na_2SiF_6 occur only above 1275° F. Hence, cryolite cannot be called a "flux," and sodium silicofluoride can be so designated only under certain conditions.

As the absorption of Al_2O_3 in the crystal lattice of sodium silicofluoride takes place not below 1250° F., the refining temperature must be selected accordingly. The absorption of Al_2O_3 by Na_2SiF_6 is due to the formation of Na_3AlF_6 and SiO_2 (probably in solid solution) and of SiF_4 gas, which plays an important part in loosening up the gas-tight oxide films. The alpha-Al_2O_3 was always found to be less reactive than the gamma-Al_2O_3. Ha (1b)

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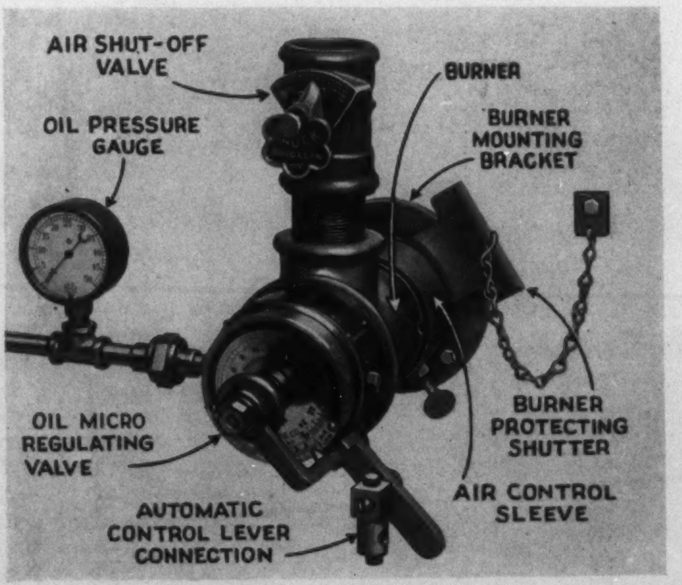
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Spot Welding

A Composite

The application of spot welding in joining sheet metal structures, already growing rapidly, has been given tremendous impetus by the current boom in aircraft manufacturing. Here, as elsewhere, its susceptibility to rapid, automatic production, the cleanness of the welded joints, concentration of the heat at highly localized points, and other factors have made spot welding particularly attractive.

But successful spot welding depends on accurate control of the welding variables and careful operating technique, as is pointed out by C. L. HIBERT of Consolidated Aircraft Corp. ("Process Control of Spot Welding," *Iron Age,* Vol. 145, Mar. 7, 1940, pp. 43-47; Mar. 14, 1940, pp. 31-34). Welding factors consist of time of current dwell, electrodes, pressure on electrodes, contact resistance, and current intensity. Process control comprises control of equipment, personnel, design, supervision, and inspection.

Spot welding of stainless steel (18/8) that contains no columbium or titanium requires a short time, to prevent carbide precipitation and its deleterious effect on corrosion resistant properties. Low current is used for thin gages. A long period of timing, on the other hand, is essential for welding aluminum alloys, to prevent the zone of fusion from reaching the exterior surface of the sheet. For welding steel other than stainless, periods of current dwell above 15 cycles give best results, possibly because of the working of the weld by electrodes while the weld is still plastic. S.A.E. 4130 and 4140 steels must be normalized after spot welding, for the welds are brittle.

Electrodes should be water-cooled to within a short distance of the welding end, because current density is very high. Copper has been used extensively as an electrode owing to its good conductivity, but it is too soft for welding aircraft materials. A number of copper alloys are on the market and they seem to stand up well in service. A satisfactory electrode for welding aluminum alloys is still not available.

The shape and design of tips vary with the metals to be welded. For stainless steel, larger diameter tips are not needed and it is also possible to sacrifice electrode conductivity for higher hardness. The ideal electrode tip has a spherical end, but this is difficult to maintain. Therefore, a 3° cone is used for steels, and from 7° to 11° for aluminum alloys. Flat tips necessitate high electrode pressures. An electrode material must be harder than the material welded, should not alloy with the work, should have a high melting point, and should have a conductivity higher than that of the material welded.

When electrode pressure has been selected, it must remain constant. For aluminum alloys, where the resistance approaches that of copper, high amperages are needed. The surface of the material must be absolutely clean, and the high-resistance oxide coating on aluminum alloys should be removed. Scaled steel parts must be pickled or sand-blasted.

The current density for spot welding aluminum alloys in aircraft construction is from 5,000-30,000 amps., and for 18/8 stainless steel 1,000-5,000 amps. Aluminum alloys are weak in tension and torsion, and therefore welds should be applied so they are stressed in shear only. Stainless steel is an ideal material for spot welding, for the welds are strong in either shear, tension or torsion. Spot welding for aluminum alloys is limited by army and navy bureaus to the following alloys: 12 ST and 24 ST Alclad, 52 S and 53 ST for extruded shapes. In long seams in aluminum alloys, a rivet at each end and rivets at regular intervals should be used to prevent tension failures from starting.

The application of spot welding in the construction of railroad passenger cars is described by W. A. STANIER ("Lightweight Passenger Rolling Stock," *Machinery, London,* Vol. 55, Jan. 18, 1940, pp. 424-428). A low-alloy, high-tensile steel is used for underframes and bogies, and contains 0.20% C max., 0.3 Si max., 1.4-1.6 Mn, 0.06 P max., 0.06 S max., 0.1 Cr max., and 0.6 Cu max., and has a yield point of 51,500 lbs./in.^{2} and tensile strength of 83,000 lbs./in.^{2} Side panels are of ordinary low-carbon (0.07-0.08% C) sheet, while the roof is of galvanized panels. Joining is done by arc or spot welding.

Arc welding is used mainly for the frames, and spot welding for the panels, roof, etc. The only serious difficulty is the deleterious effect of the zinc on the galvanized sheets on the copper electrode tips. The frames are treated with a wash of phosphoric acid and methyl alcohol before spot welding the panels onto the frames, in order to retard corrosion between frame and panel.

Some of the difficulties encountered in spot and seam welding of aluminum and magnesium alloys are investigated and discussed by C. HAASE ("Punkt-und Nahtschweissung von Leichtmetallen," *Z. Ver. deut. Ing.,* Vol. 84, Feb. 10, 1940, pp. 89-96). Precipitation hardening on subsequent heat treatment is greater for small spots than for large; in seams with very close spots precipitation hardening can eventually be obtained by the welding heat itself without subsequent heat treatment. It is shown that the strength of spot and seam welds is just as good as that of riveted joints.

Other tests, on spot welds on aluminum-magnesium alloys, by J. HERENGUEL & F. SANTINI ("Propriétés Mécaniques de Soudures par Points sur Aluminium-Magnesium," *Métaux et Corrosion,* Sept. 1939, pp. 122-125) showed the welds to have good corrosion resistance and high fatigue limits.
X (2)

New Convection Firing System

"CONJECTO-FIRING: A NEW SYSTEM."
H. M. HEYN (Surface Combustion Corp.) *Ind. Gas,* Vol. 18, Mar. 1940, pp. 6-7. Descriptive.

For lower-temperature operations, such as tempering, convection heating is faster and more uniform than radiation heating. This accounts for the present widespread use of recirculated air furnaces for temperatures up to 1350° F.

Convection heating depends on circulating a large volume of gas, but unfortunately, when operating the usual furnace at low temperatures, the burners are necessarily turned down with consequent reduction in the volume of the combustion products. To circumvent this attempt to "ride two horses going in opposite directions," a new firing system (Conjecto-Firing) has been developed, in which an additional volume of air is introduced at low temperature. The additional air is immediately mixed with the hot combustion products on being introduced in the furnace.

This is accomplished by the use of twin burner nozzles in the same casting; each nozzle has an individual tunnel, one tunnel vertically above the other. At low temperatures one nozzle functions in the usual manner, completely burning the air-gas mixture within the tunnel. The gas supply to the other nozzle is shut off, and the air is injected through the nozzle and tunnel. The air leaves the tunnel at a fairly high velocity, and quickly combines with the hot products of combustion from the other tunnel.

Hence, at the lower temperatures it is possible to produce a large volume of hot gases, which results in quicker and more uniform heating through convection. At higher temperatures such as those required for annealing, hardening, normalizing and carburizing, both nozzles function in the usual manner, completely burning a correctly proportioned air-gas mixture. The double-nozzle feature, since the burners can be adjusted so that the upper and lower nozzles are of different capacity, thus provides a unique system for close temperature control—at hardening as well as tempering temperatures.

The use of burners employing this firing system makes possible a much greater temperature range, from 600° to 2000° F. (2)

2a. Ferrous

The Welds in a Collapsed Bridge

"EXAMINATION OF WELDED STEEL SPECIMENS FROM THE HASSELT BRIDGE." L. REEVE. *Trans. Inst. Welding,* Vol. 3, Jan. 1940, pp. 3-13. Committee report of exhaustive tests.

In 1938 the Hasselt Bridge in Belgium collapsed. Because the bridge was a welded structure, many persons were quick to attribute its failure to the use of welding and to proceed assumptively to a general condemnation of the welding of such structures. A committee of the Institute of Welding therefore investigated the steel and the welds in this bridge to determine whether the steel, the joining method or some procedural detail had been at fault.

The ordinary chemical analyses of the rolled steels used were normal, with the exception of a somewhat higher sulphur and phosphorus content in some specimens than is allowed by British specifications, and one case of a manganese content above 1%. The latter, however, is not abnormal if a medium high-tensile steel was required. A steel casting attached to the lower chord of the bridge contained sulphur and phosphorus of 0.095% and 0.084%, respectively, which are considered to be too high for an important unit of a fusion welded structure. There is evidence also of marked sulphur and phosphorus segregation in several specimens. Mechanical tests on the steels indicate that tensile strength and ductility were on the whole satisfactory. Izod impact tests on the steels are definitely on the low side in the case of a heavy 2.2-in. (flange) plate, and to a lesser extent in the case of an 0.8-in. plate.

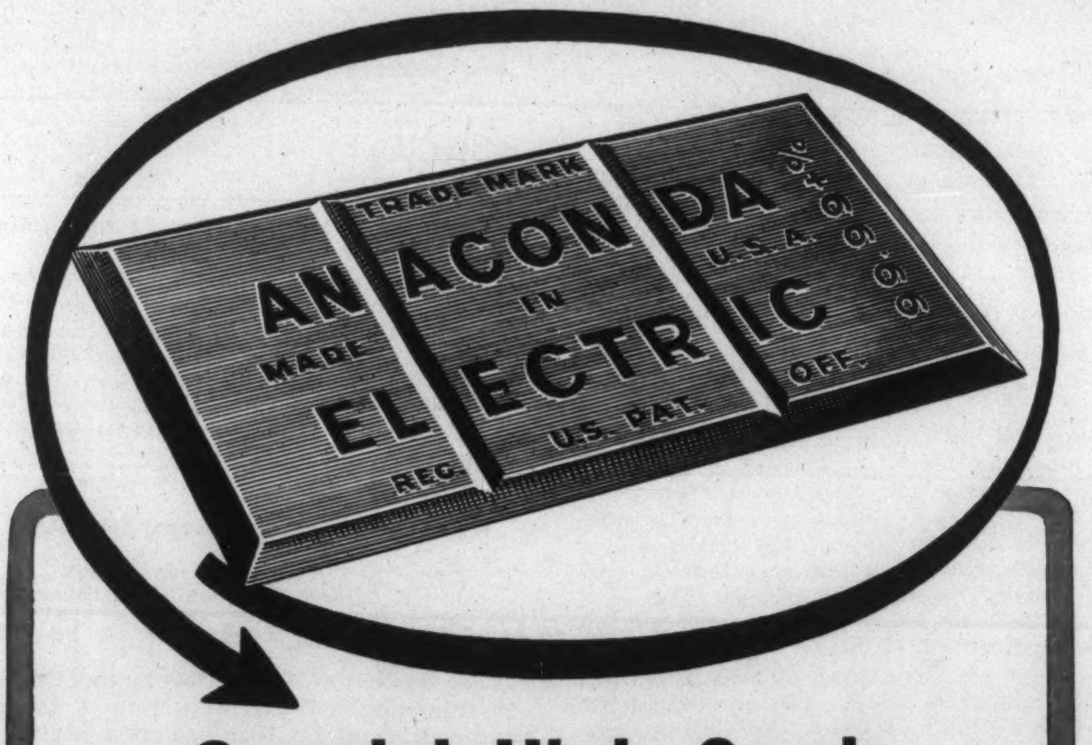
Chemical analyses of the weld metal are normal for covered electrodes except for a somewhat higher phosphorus content than present in most Class A weld metal. One specimen indicates the use of a lightly coated electrode; this weld was found to be almost completely cracked through the throat. Micro-tensile and notched bar tests on the welds show tensile strength in some cases rather high, with elongation and reduction of area figures ranging from very good to poor. Two notched bar tests reported were 41.5 and 28.4 ft.-lbs., respectively. Vickers hardness measurements in the important zones adjacent to the welds were carried out in the case of 2 butt and 4 fillet welds. No exceptional hardness figures were reported.

Serious defects in the macro-structure of several of the welds were noted, of which the most important are the cracks at the root of one important butt weld shown. It is considered that these developed as the result of the complete absence of a sealing run at the back of this weld. The high sulphur (0.095%) in the casting may also have accentuated the cracking tendency. There is evidence of an unsuccessful attempt to seal up a pipe cavity in this casting by a single run of weld metal. A cracked fillet weld is shown together with a badly blowholed butt joint containing microcracks, and there are other welding defects, more or less serious.

The most unsatisfactory feature exposed by the examination is the defective welding just discussed. The causes of failure are clearly evident as stress concentration due to major defects resulting from improper design and poor workmanship in welding. The design of the bridge is hardly at fault since it is understood a number of bridges of similar design are still giving satisfactory service. Nor can the quality of the steel be blamed, for although the steel employed may have been unsatisfactory in some respects, the whole blame for the collapse of the bridge cannot, with justice, be placed on the steel alone.

The main cause for dissatisfaction with the steel is the comparatively low Izod value in the "as received" condition. However, the exact practical significance of low Izod value is difficult to state, and there is no definite evidence that such low Izods can be the direct cause of the type of crack known to have developed in this or similar welded bridges. While steels with such low Izods as reported cannot be regarded as entirely satisfactory, there is no definite evidence that had the Izod values been consistently above, say, 30-ft. lbs. this failure would not have occurred.

Again, therefore, there can be little doubt that the most unsatisfactory feature exposed by the investigation is the defective nature of the welding procedure and technique, which have resulted in the grave welding defects described. In 4 out of 5 Vierendiel bridges in which the welding technique was identical with that employed on the Hasselt Bridge, fissures have been discovered either in the welds or in the gusset flanges, and in certain cases distinct cracks have developed in the lower chord



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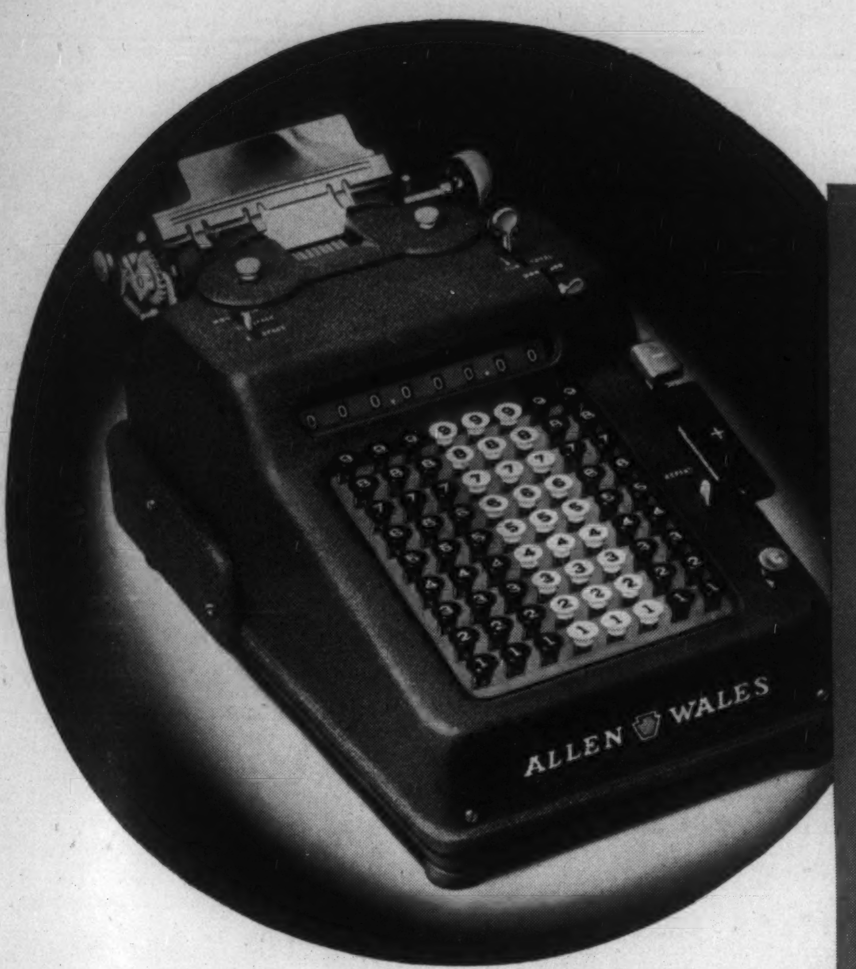

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as a result of rupture in the gusset flange. Also, examination by others of portions of the Hasselt Bridge recovered from the bed of the canal led to the conclusion that the initial rupture occurred in a weld; the failure, taking place abruptly, caused a sudden redistribution of the stress and brought about the failure of the lower chord as the result of shock.

The Committee examined this same weld and also found serious cracks present, which the Committee felt had been accentuated by the complete absence of fusion at the root and probably by the high sulphur content in the attached casting which would favor cracking in the first bead. The casting also contained some serious defects in porous areas that had been subjected to a haphazard attempt at repairing. No attempt had been made to cut out the porous area or the unfused area at the root of the Vee of the weld.

The undercurrent of thought in the Committee's report is that such welding procedure and gross defects could not occur in England since they would not be tolerated in the rigid regulations for and inspection of welded structures. [This statement could be applied as well to American standards, which would not tolerate welds so defective as these seemed to have been. Therefore, the collapse of the bridge is not an indictment of welding for such structures, but rather an indictment of poor welds made with faulty welding procedure.—W.B.] WB (2a)

Building-Up Tools and Dies

"Welding Tool Steels." H. A. Gonser (Darwin & Milner, Inc.) *Steel*, Vol. 106, Feb. 5, 1940, pp. 66, 68. Practical.

The process of "casting" tool steel deposits on tools and dies by the usual welding procedure is not very satisfactory. A really workable method of welding tool steels would afford not only a reliable means of quickly repairing alloy tools and dies, but of producing dies consisting of a cast iron base with tool steel working surfaces or edges.

Proper application of the following method, as applied to built-up layers on cast iron, overcomes the difficulty encountered in "welding-on" air hardening tool steels. Deposits from 4 different types of rod are placed one on top of another in sequence. The first deposit is made with a soft nickel-alloy rod, which fuses to the base metal very well and gives a good mechanical joint. The second layer is made with a mild steel rod containing a small amount of tungsten to give a deposit with hardness of 30-35 Rockwell C. The third deposit is made with a low tungsten-molybdenum steel rod, resulting in a surface of 45 Rockwell C. The fourth and last layer is made with a high tungsten-molybdenum rod to give a surface of 58-60 Rockwell C, sufficiently hard to use as a cutting edge. The first layer keeps the harder metal deposited later from chipping off.

An example of the successful use of this method is an oval combination forming and trimming die, 5 ft. in circumference, with 9-in. opening at the largest point, cast from Meehanite into a ring weighing 480 lbs. A ½-in. step, ⅜-in. wide, was milled into the ring and a cutting edge built up in this step by using the 4 rods as described above. Before depositing the first layer, the casting was preheated to 400° F. A d.c. machine and ⅛-in. rods were used. Another example is a combination blanking and forming die made of 2 castings welded together. The cutting surface was deposited at one edge by this method, and the opposite corner was rounded off to give a forming edge. MS (2a)

Tempering High Speed Steel

"The Tempering of High Speed Steel." M. Cohen & P. K. Koh (Mass. Inst. Tech.) *Trans. Am. Soc. Metals*, Vol. 27, Dec. 1939, pp. 1015-1051; with discussion. Original research.

The tempering of high speed steel is a vital part of its normal heat treatment because of the accompanying secondary hardening. Quenched or hardened high speed steel softens appreciably when tempered in the range generally used for plain carbon and low alloy tool steels, but when the tempering temperature is raised to 1000°-1100° F., high speed steel develops a secondary hardness of the same order of magnitude as the original quenched hardness. Thus, the quenching stresses may be relieved to a substantial degree without much, if any, sacrifice of hardness.

The mechanism of tempering and secondary hardening of 18-4-1 high speed steel was investigated on hardened specimens tempered at several temperatures for times ranging from 1 min. to several hundred hrs. At some temperatures single tempering was directly compared with multiple tempering.

Secondary hardening is attributed to the precipitation of complex carbides from the residual austenite and the transformation of this austenite into martensite. *The austenite transforms during the cooling from the tempering temperature, rather than during tempering itself.* The amount of transformation depends chiefly on the time and tem-

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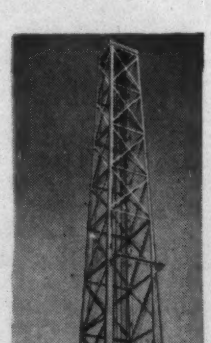

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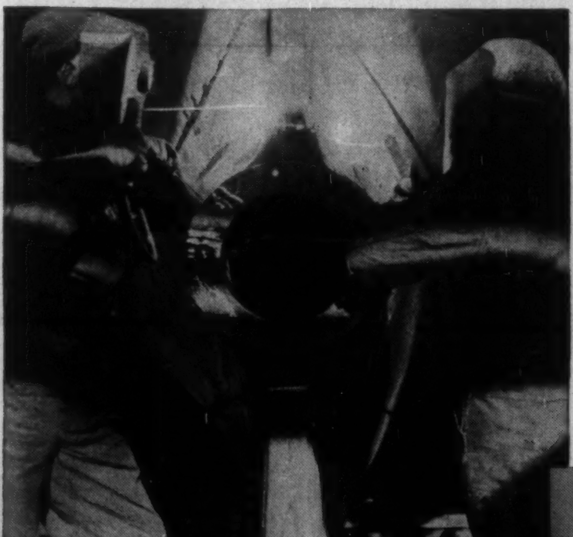

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perature of the tempering treatment, assuming constant hardening conditions, and seems to be independent of cooling rates. Furthermore, the cumulative amount of austenite transformed is independent of the number of intermittent coolings to room temperature.

The transformation during cooling after tempering causes an expansion at relatively low temperatures, and hence results in "frozen" internal stresses. Longer single-tempering time fails to remove these, but if multiple tempering is used the transformation occurs in increments during successive coolings. The stresses are thus relieved and the martensite is toughened by the subsequent heatings.

Prolonged tempering at 1150° F. causes the austenite to transform isothermally at that temperature, but the product is relatively soft. On the other hand, the residual austenite may be transformed isothermally if the cooling from the tempering temperature is stopped within the proper temperature range, and this product is not a great deal softer than the martensite formed by continuous cooling.

The authors and at least one discussor believe that low temperature isothermal transformation, say at 400° F., may have important commercial application because of the generally improved properties and freedom from transformation stresses of the product. FPP (2a)

Cracking of Welds

"The Cracking Tendency of Welds Proper with Special Reference to the Chemical Composition of Structural Steel." Elis Helin & Sven Svantesson. *Trans. Inst. Welding,* Vol. 3, Jan. 1940, pp. 14-29. Research report.

The following factors appear to be of major importance in the cracking of welds during cooling: Inclusions of slag and unfused particles from the electrode coating; segregating constituents from the weld metal or the parent metal; unavoidable stresses from cooling shrinkage; the development of internal gas pressures due to occluded constituents from the coating or from the development of carbon oxides in the mother liquor. Sulphur seems to exert an especially pernicious influence, while carbon and phosphorus in themselves have little effect.

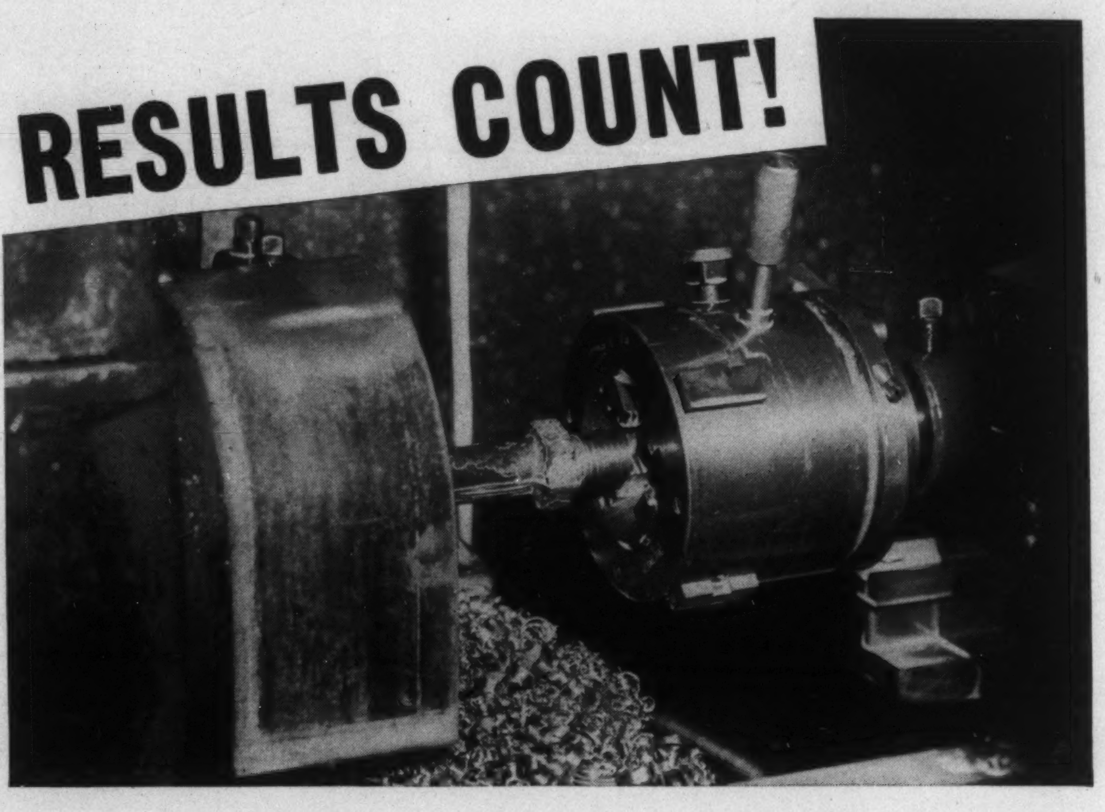
The common and economic alloying elements, carbon, manganese and silicon, may be used to any extent helpful in the promotion of stronger and better qualities so long as the steel is weldable, *i.e.* not hardenable above certain limits during the normal welding procedure in the "cold" condition. Other alloying elements contributing to the attainment of stronger and better structural steels may also be employed. In regard to phosphorus, as high a content as 0.070% appears to be permissible. With the majority of electrode types, sulphur must be considered a potential source of trouble, yet electrode types are available that successfully weld high-sulphur plate.

In spite of the impression obtained from the welding literature that weld cracking is an obsolete phenomenon, it will occur sporadically with electrodes and steels with which no trouble was formerly encountered. The cause may be major fluctuations in parent metals, electrodes and welding conditions, or perhaps to unhappy conjunctions of such minor fluctuations. Crackproofness, however, is generally obtained with a sacrifice of welding utility and economy. The problem of weld cracking is a major one of electrode and welding development.

A smooth contour running flush into the parent metal is considered ideal and attainable with weld metal of medium fluidity and a good slag covering. With electrodes yielding such weld metal it is easy to deposit just enough metal for the joint in question, while with low-fluidity weld metal it is often necessary to superimpose a considerable amount of metal on the ideal contour of the joint. The ideal electrodes deposit multilayer welds of evenly-normalized structure, while low-fluidity weld metal shows a heterogeneous, rainbow structure. Since medium fluidity is obtained with a higher arc energy, the shrinkage stresses are greater than for a low-fluidity weld metal.

The convex fillet contour is treacherous since cracks can easily develop in the interior without becoming visible on the surface. The concave fillet gives the most favorable stress distribution but development of crackproof electrodes yielding this type of contour is most difficult because of the high temperature required to give weld metal of good fluidity. The concave fillet is safe because any cracks that may form are clearly visible on the surface. A suggested method of avoiding crater cracks is to prevent the crater from forming by having a second welder take the arc away with a new electrode and continue welding.

Inclusions in the core wire are considered to affect weld cracking, since they are highly refractory and tend to freeze into the weld metal. Indications are that neither hydrogen nor nitrogen is a major cause of weld cracking. However, the reaction between iron oxide and carbon to form iron and carbon monoxide is a most important



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consideration, since the internal pressure built up by carbon monoxide formation may cause rupture. In order to prevent the carbon monoxide pressures going too high, larger content of manganese and silicon deoxidizers are required. A considerable amount of tabulated data is shown and discussed for a number of tests carried out with various slag compositions and core wire analyses. WB (2a)

Pack Hardening S.A.E. Steels

"Some Factors Affecting Carburization." T. A. Frischman (Eaton Mfg. Co.) *Heat Treating & Forging*, Vol. 26, Feb. 1940, pp. 65-67. Investigation.

The rates of carburization of several steels by different grades of carburizing compound were studied, using 1 in. round, 6 in. long specimens. Total time of the carburizing cycle was 15 hrs., the carburizing temperature was 1650° F., and the pot containing the specimens was cooled in air from carburizing temperature.

The carbon content at various depths was determined for 4 steels: S.A.E. 2315; a 0.54% Cr, 0.63 Ni, 0.10 V steel; a 0.74% Cr, 0.15 Ni, 0.08 V steel; and S.A.E. 1015 steel—all with 0.15-0.20% C. After carburizing, the S.A.E. 2315 had a lower carbon content at the surface, and at any depth beneath the surface, than any of the other steels. The other 3 steels differed only slightly in the carbon contents of their cases at the surface or at various depths. Further checks, in which S.A.E. 3115 was also tested, showed the latter to carburize with appreciably higher carbon cases than S.A.E. 1015 and much higher than S.A.E. 2315.

Routine screening of compound plays an important part in obtaining consistently good carburizing results. Accumulation of fines and dust increases the weight of a given volume of compound, the pots become packed more densely, and a gradual change in case characteristics may result.

Some quantitative data on the advisability of using *coarse* screenings were obtained by dividing screenings that passed through 3/16-in. sq. openings into very fine and coarse particles, the latter 1/16-1/8 in. in dia. Samples of S.A.E. 4620 steel were carburized for 15 hrs. at 1680° F. in each grade of compound and direct quenched. The bar carburized in the fine compound had a Rockwell C hardness of 63; the bar treated in coarse particles had a hardness of 57. The fine-carburized bar had a case depth of 0.075 in. whereas the coarse-carburized bar had a 0.087-in. case.

Other tests showed that coarser screenings could be used effectively as far as carbon concentration is concerned, but packing in large boxes makes too dense a mass, and for consistently good carburizing results it is better to adhere to the use of larger size particles—such as are employed in regular production mixes. When extremely fine and coarse particles exist together in a compound, variations in results from day to day may occur.

The majority of users of solid compounds use charcoal-coke type high in charcoal. Average mixture used is 1 part new compound to 5 parts of old. Another type frequently used is the non-burning pitch coke compound having cellular-like particles. Some of its favorable characteristics are low dusting and burning losses, formation of high-carbon cases, and good strength at carburizing temperatures. After 17 successive runs of this compound without adding any new, and using only spent compound to make up shrinkage and screening losses, it continued to carburize as well as it did when fresh.

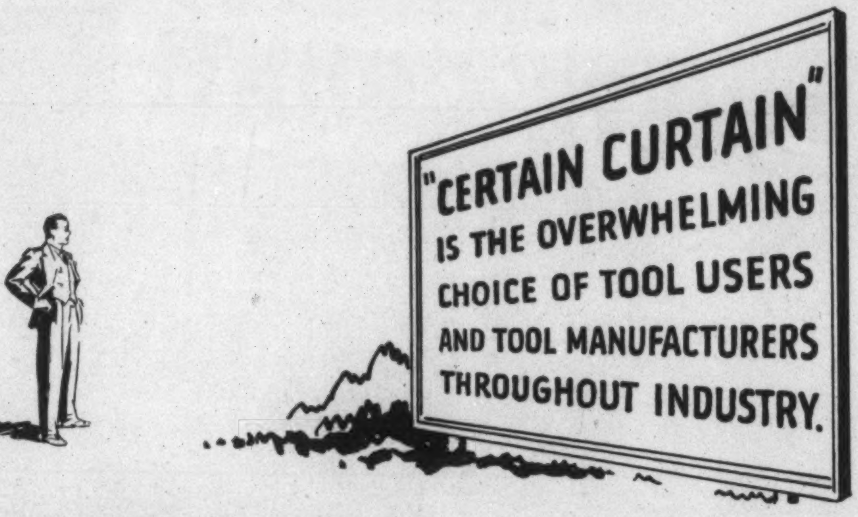
Tests and analyses, using S.A.E. 2315 steel and 2 different compounds to which sodium-carbonate was added, showed that compounds containing more than 2% sodium-carbonate (although giving generally higher-carbon cases than low-sodium-carbonate compounds) tend to cause a slight "decarburization" of the surface as compared with the carbon content 0.005 in. beneath the surface. With any compound, the corrosive effect on the pots seems to increase with increasing amounts of sodium-carbonate. MS (2a)

Peening of Gas Welds

Recrystallization-Improvement of Gas Welds ("Die Rekristallisationsvergütung von Gasschweissungen") G. Czternasty. *Autogene Metallbearbeit.*, Vol. 33, Jan. 15, 1940, pp. 17-25. Investigation.

Improvement of gas welds has often been sought through hammering while the weld is still warm. Simple annealing has also been applied, but in neither method is uniformity of treatment very likely and, generally speaking, the results have been disappointing.

Occasionally, however, hot-hammering has been responsible for striking improvement, which the author believed could be traced in each case to recrystallization occurring in a favorable temperature range. The possibility of finding how to do this regularly was investigated by making oxy-acetylene welds 22-in. long in ordinary boiler plate steel 0.6 in. thick and 14 in. wide, and subsequently giving them various high temperature treatments. The welding



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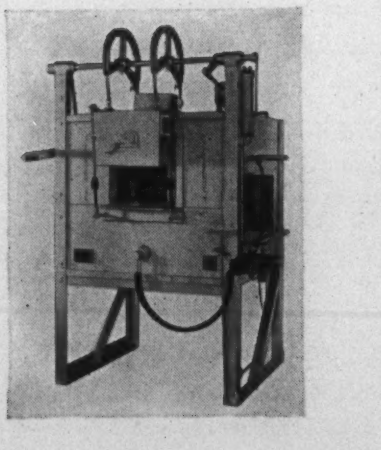

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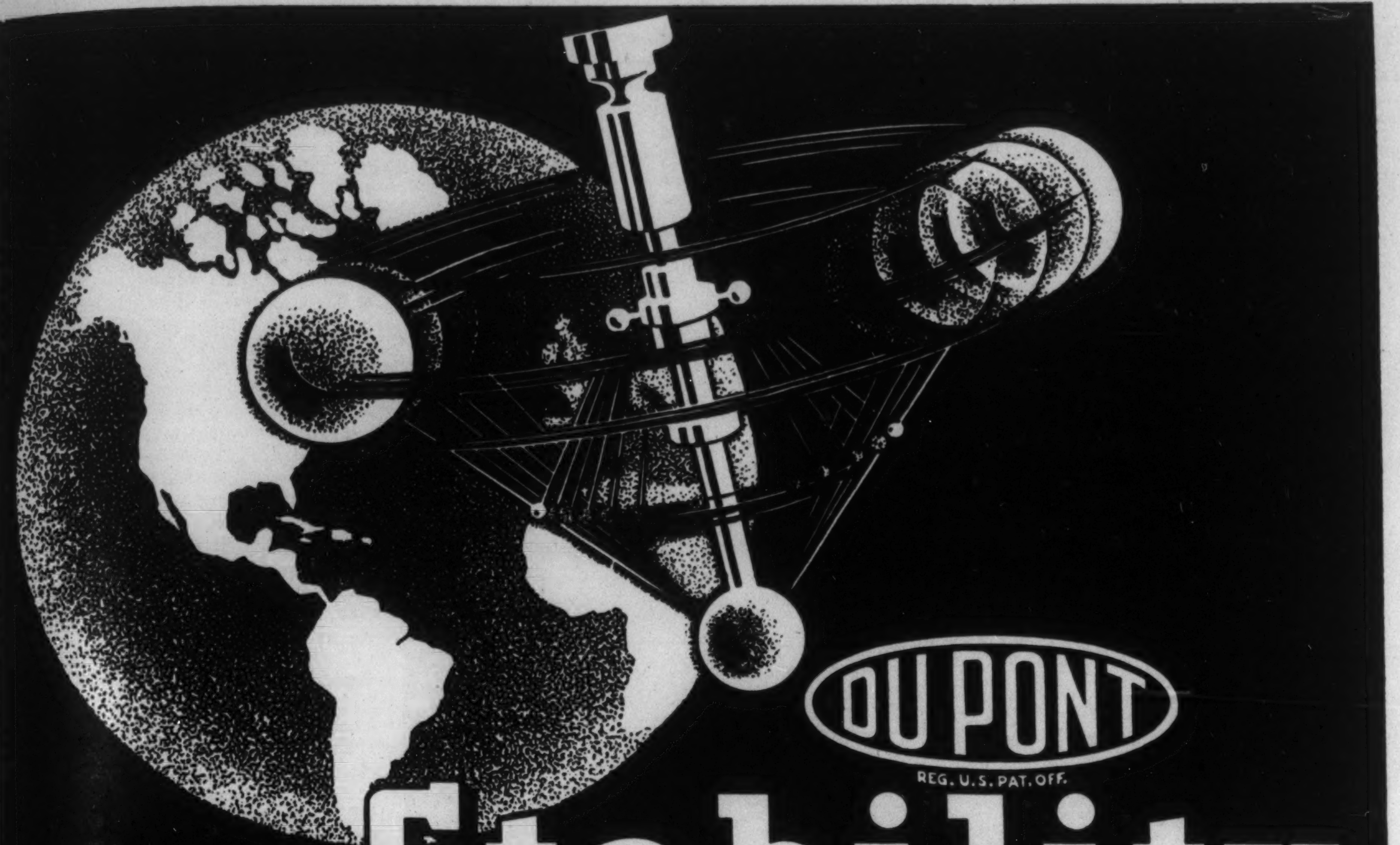

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rods were of the same composition as the parent metal, and the welds were of the "V" butt type with seal bead.

The after-treatments comprised (1) no treatment after welding; (2) torch-heating of the weld to a temperature just above the recrystallization point, and then hot rolling at 1200°-1300° F.; (3) same as 2 except that hot rolling was performed at 1300°-1475° F.; and (4) same as 3 except for a final normalizing treatment. Deformation by rolling in each case amounted to 18-28%. The welds were then tested for tensile strength, bending strength, notch-impact value, radiographic structure and microstructure.

Radiographs showed no defects. Tensile strength and particularly notch impact values were raised by hot rolling, within either of the temperature ranges studied. The final normalizing treatment was without benefit, in fact was definitely harmful. Hardly any differences were noted in the bending test results, except that all the hot-rolled welds were better than the as-welded samples. General uniformity was much improved also, as the scatter among the results for the rolled specimens was less than for the as-welded. The rolled specimens had uniform, fine grain structures, whereas the as-welded structures were coarse.

The idea seems to be to eliminate coarse grain by high deformation at relatively low temperatures, *i.e.* just above the recrystallization temperature. The special benefits of rolling are ascribed to recrystallization rather than sealing of porosity.

The usual peening or manual hammering is recommended for welds in thin plates, if reinforcement is sufficient and the proper temperature is maintained with a torch. Medium-sized sheet requires mechanical hammering, while hot rolling is best for heavy welded plate.
Ha (2a)

Heat Treating Manganese Steels

The Transformations of the Manganese Steels ("Ueber die Umwandlungen der Manganstähle") F. Wever & K. Mathieu. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch. Düsseldorf,* Vol. 22, No. 2, 1940, pp. 9-18. Research.

Manganese steels of 0-1.4% C and 2-5 Mn were studied, the amount of austenite transformed being determined magnetically during the whole transformation process. Three transformation stages were observed: A martensite stage, an intermediate stage and a pearlite stage. Contrary to widely-held views that manganese, like most other alloying elements, has no influence on the martensite point, it was established with certainty that both manganese and carbon have a definite effect on the martensite temperature, the effect of manganese being about 1/12 that of carbon.

The effect of manganese is, therefore, inappreciable in steels deoxidized with the usual small amounts of manganese. The martensite points are shifted to temperatures that are lower the greater the amount of austenite that was transformed in the intermediate stage. But if there is also partial transformation of austenite in the pearlite stage, then the temperature of the martensite point is increased. However, in steels with less than 0.5% C, no shifting could be observed.

The time of transformation in the intermediate stage is very short; the lower the temperature of transformation in this stage the more complete is the austenite decomposition, and at temperatures slightly above the martensite point the transformation goes to completion. If the carbon content of the manganese steels is very low, the martensite and intermediate stages coincide.

In the pearlite and intermediate stage, carbides are also formed; the magnetization curves showed that in general the Curie point of the carbide shifts to higher temperatures with decreasing transformation temperatures. The difference in structure is more distinct in low-carbon steels, as the pearlite is easier to etch than the intermediate structure. The pearlite transformation takes place more actively the higher the carbon content of the steel, but below 0.3% C the transformation becomes so slow that it can hardly be observed.
Ha (2a)

Resistance-Welded Tubes

"Tubes Electrically Welded." John B. Borgat. *Steel,* Vol. 106, Mar. 11, 1940, pp. 52, 54, 79-80. Descriptive.

A new method, not yet in commercial production, makes possible the accurate control of grain structure in the manufacture of electric resistance-welded tubes. A special welding-machine uses flat contactors instead of the usual roller-type electrodes.

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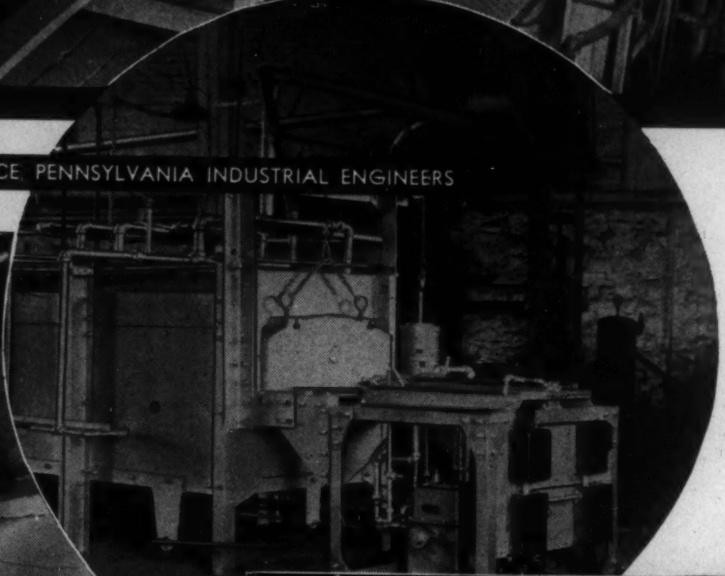

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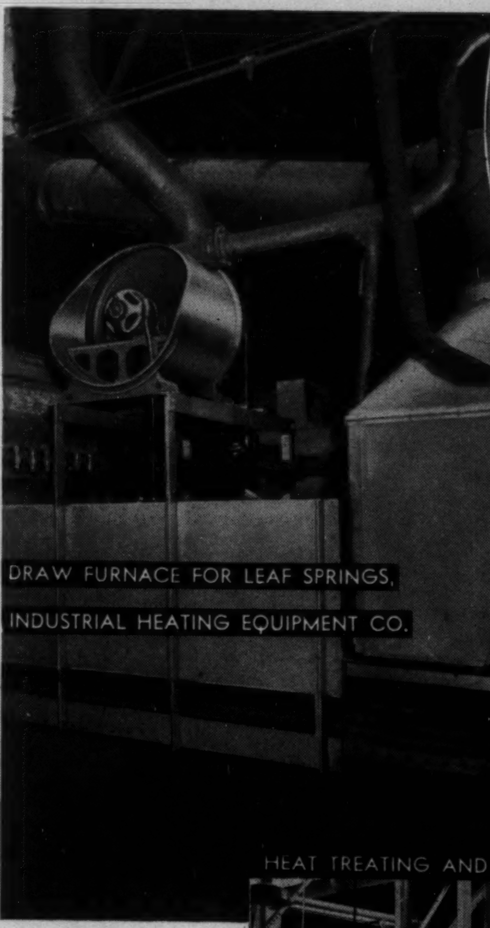

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MS (2a)

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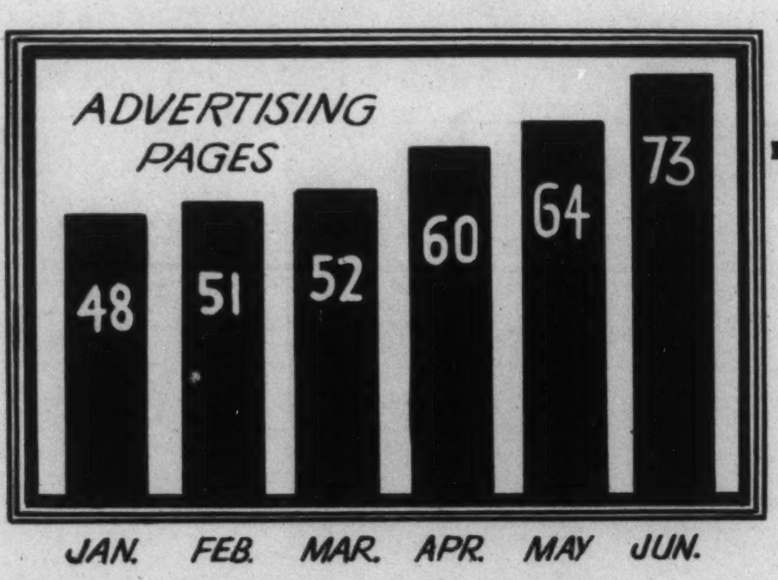

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Gas-Welding Boiler Plates

GAS FUSION WELDING OF BOILER PLATES OF LARGER THICKNESS IN ORDINARY AND HIGH-STRENGTH GRADES OF CARBON-SILICON STEEL WITH DIFFERENT WELDING ROD MATERIALS ("Studien zur Gasschmelzschweissung von Kesselblechen grösserer Dicke in den Festigkeitsstufen 2 und 4 mit verschiedenen Zusatzwerkstoffen") A. THEIS & K. L. ZEYEN. *Autogene Metallbearbeit.*, Vol. 33 Mar. 1, 1940, pp. 57-65. Investigation.

The German standards require for gas-welded boiler plate a rating of 0.9, that is, a notch-impact value in the ordinary-strength grade of at least 8 and in the high-strength grade of at least 6 m-kg./cm.^{2} At present, arc welding is generally and preferably applied in boiler plate welding; experiments were made to determine if it is possible by careful technique and rod selection to obtain gas-welded boiler plates in 1/2 in. and 1 1/4 in. thickness, with the rating 0.9.

Eleven different welding rod materials were tested on 2 steels: "Izett 2" with 0.16% C, 0.18 Si, 0.50 Mn, 0.010 P, 0.021 S; and "Izett 4", with 0.27% C, 0.27 Si, 0.56 Mn, 0.018 P and 0.021 S. Best results were obtained with 4 rod materials, all containing 0.12-0.19% C, 0.30-0.41 Si, 0.95-1.01 Mn and 0.83-0.89 Ni; in addition, one rod contained 0.35% Cr, another 0.27% Mo, the third 0.25% V and the fourth 0.36% Cr and 0.27 Mo. Welds with these rods gave fully satisfactory results with the 1/2-in. sheets in the normalized slate, the impact strength being even higher than that required. Sheets of 1 1/4-in. thickness had the required impact strength in the normalized state, but the tensile strength was below requirements in "Izett 4" and the bending angle far below the required value for both grades.

Multilayer welding gave as good results in 1/2-in. plate as a normalizing treatment, but had no advantage in 1 1/4-in. sheets. The rating 0.9 could, therefore, be obtained safely only with sheets up to 5/8-in. thick in right hand (progressive) welding. Usually in electric welding multiple layers are applied, and good strength values are obtained even without subsequent heat treatment; in gas welding, the coarse grain (caused by the large melt and the consequent slow cooling) can be recrystallized to fine grain, in order to obtain desired mechanical strength, only by normalizing.
Ha (2a)

Bright Annealing Stainless

BRIGHT ANNEALING OF CHROMIUM STEELS ("Blankglühen von chromhaltigen Stählen) O. DAHL & F. PAWLEK. *Stahl u. Eisen*, Vol. 60, Feb. 15, 1940, pp. 137-142. Original research.

The problem of bright annealing is much more difficult with high-chromium stainless steels of the 18-8 type than with ordinary sheet steel. The oxide layer of high chromium steels is more difficult to reduce and traces of moisture in the atmosphere spoil the surface appearance.

The equilibria at various temperatures between hydrogen and water vapor, and carbon monoxide and carbon dioxide gas mixtures and chromium metal were determined. These show that protective atmospheres containing carbon monoxide are not suitable for bright annealing high-chromium steels. Hydrogen is, therefore, about the only available gas. Hydrogen is most readily obtained from the cracking of ammonia and, because of the low moisture content, this is a most desirable source of hydrogen. However, the high-chromium steels pick up nitrogen very readily from cracked ammonia gas, and this factor was therefore investigated.

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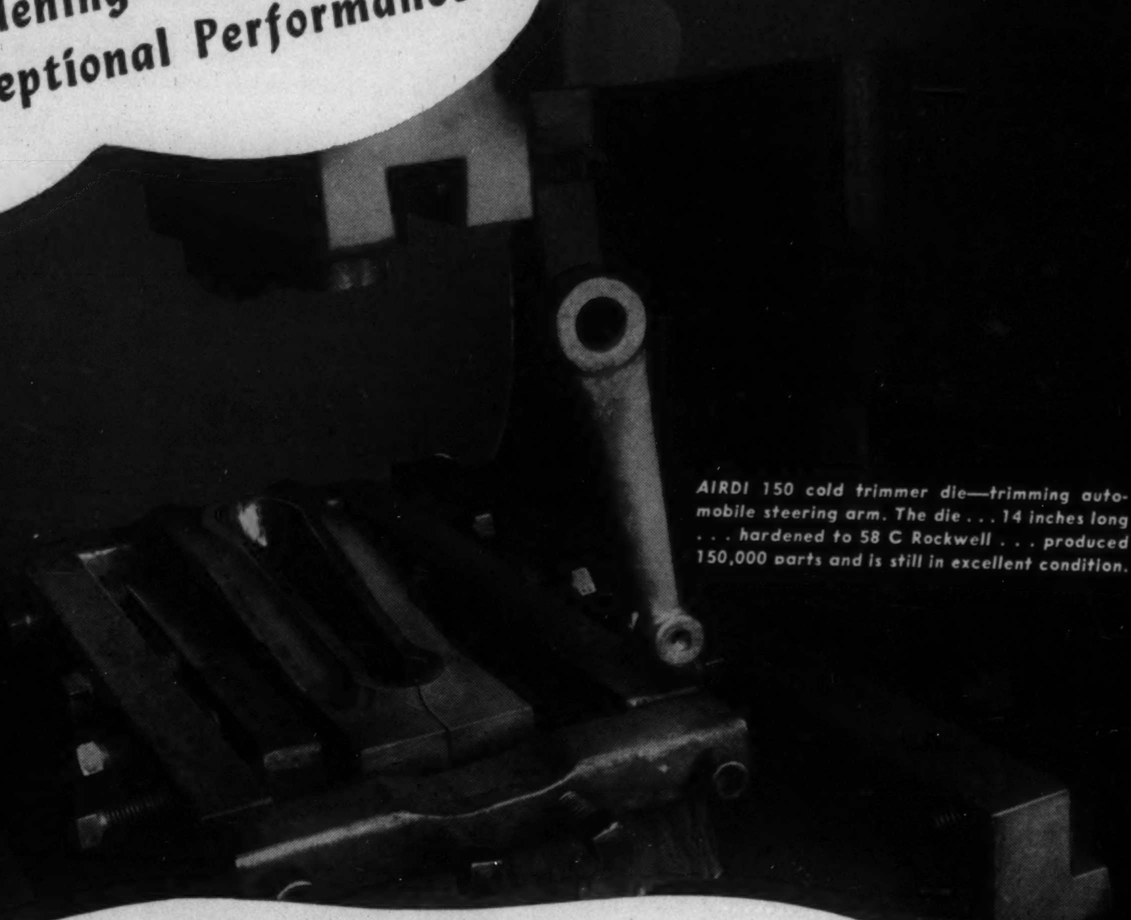

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The nitrogen absorbed goes into solid solution, and raises the tensile strength about 30% and lowers the elongation about 20%. Nitrogen pickup does not lower the general corrosion resistance appreciably, and intercrystalline carbide precipitation is even decreased slightly after annealing in cracked ammonia. SE (2a)

Arc Welding in Controlled Atmospheres

"ARC WELDING IN CONTROLLED ATMOSPHERES." G. E. DOAN & M. C. SMITH (Lehigh Univ.) *Welding J., N. Y.*, Vol. 19, Mar. 1940, pp. 110-s—115-s. Research.

Experimental welds were made in controlled atmospheres of helium, argon, nitrogen and chlorine, all of commercial purity, using electrodes of (1) plain low-carbon steel and of (2) high-purity carbonyl-iron. The electrodes were used bare and with spray-coatings of metallic antimony, the latter to reduce, by alloying, the surface tension of the molten weld metal.

Complete absence of crater formation was observed during welding in atmospheres of all the gases tested, irrespective of the electrode used or of the application to it of an antimony coating. Only in the presence of a considerable admixture of oxygen or of atmospheric air was a crater formed. That the antimony was effective in producing a reduction in surface tension was definitely indicated by the spreading of the weld-metal.

The addition of an antimony coating also lowered the percentage of oxygen required in the arc atmosphere to produce the crater effect, although it did not cause crater formation. No new crater effects were noted in the use of chlorine as a welding atmosphere.

The observed experimental evidence bears out the results of previous investigations: Crater formation in the welding arc depends primarily upon the presence of oxygen in the arc atmosphere. In addition the present work shows that: (1) Reduction of metallic surface tension by suitable alloying additions favors crater formation; (2) the use of a diatomic gas as an arc atmosphere similarly favors crater formation; (3) these effects alone or together are not sufficient to produce cratering in the complete absence of oxygen, although each lowers the percentage of oxygen required to cause crater formation.

Therefore, the mechanism of crater formation is apparently not—as has been suggested—dependent alone upon surface tension effects or upon the presence in the arc atmosphere of a diatomic gas. The actual mechanism by which, in the presence of oxygen, the crater is produced under the welding arc, still awaits explanation. CEJ (2a)

Annealing Steel for Drawing

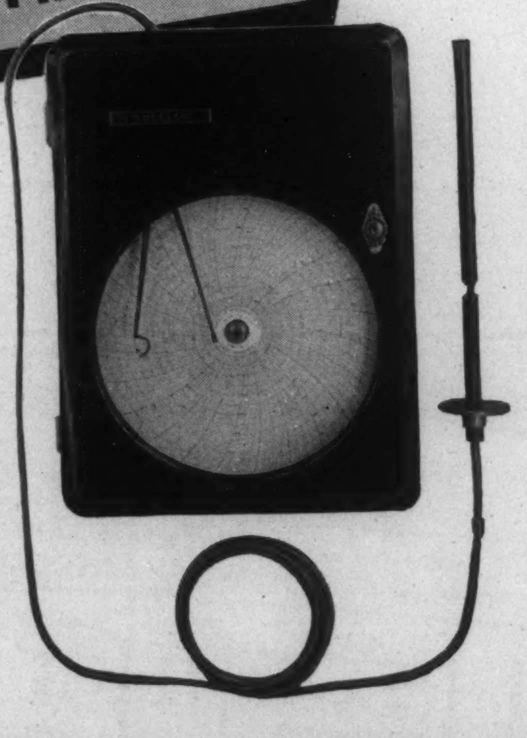
"HOW TO ANNEAL FOR SUPERIOR DRAWING QUALITIES." J. N. CROMBIE (Carnegie-Illinois Steel Corp.) *Steel*, Vol. 106, Mar. 18, 1940, pp. 44-47. Investigation.

Using a typical enameling steel (0.06% C, 0.33 Mn, 0.009 P, 0.026 S and 0.008 Si), shells were drawn from blanks, 20½ in. in diam. and 0.024 in. thick, to a diam. of 8 in. and depth of 9¼ in. in 4 operations without intermediate anneal. Strips 1 in. wide were cut vertically from a shell and separately annealed at 1000°, 1050°, 1100°, 1200°, 1300°, 1400°, 1500°, 1600° or 1700° F., held at temperature for 2 min., and cooled in air.

Metallographic examination revealed that annealing below 1100° F. caused no change in microstructure, but annealing at 1200°-1500° F. caused grain coarsening. Further enlargement occurred at 1600° and 1700° F. Exaggerated grain growth was developed when deformation was about 10%.

To define the deformation range, specimens were pulled in a tensile test machine to various definite percentages of elongation from 5 to 25%, and then annealed simultaneously with the test strips from the drawn shell. The results showed that for elongations of 5, 7.5 and 10%, the grains grow much larger than for elongations of 15% or more, irrespective of annealing temperatures up to 1600° F. They illustrate two familiar laws of recrystallization: The greater the degree of cold work, the lower the temperature for recrystallization; and final grain size depends more upon degree of cold work than upon annealing temperature.

As practically every drawn article has certain areas which have been cold worked within the critical range of 5-15% and are thus subject to critical grain growth, either of two methods may be followed, depending on the severity of subsequent working. The first is to anneal below 1100° F., which relieves drawing strains and produces satisfactory results provided subsequent operations are mild. If succeeding draws are severe, annealing should be conducted above the transformation temperature, which for this steel is 1625° F. MS (2a)



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Annealing of Brass

"Recovery and Recrystallization in Long-Time Annealing of 70-30 Brass." S. E. Maddigan & A. I. Blank (Chase Brass & Copper Co.) *Metals Tech.*, Vol. 7, Feb. 1940, 21 pp. Original research.

A study was made of the processes of recovery [obliteration of the mechanical effects of cold working] and recrystallization during low-temperature annealing of cold-worked 70-30 brass. Two annealing temperatures were used, one slightly above and the other slightly below the accepted recrystallization temperature. After various annealing times up to 2740 hrs., microscopic studies were made in addition to tensile strength measurements and very sensitive conductivity measurements.

The process of softening seems to be divided into 2 parts: (1) a stage of pure recovery preceding any microscopic evidence of recrystallization; (2) a second stage in which recrystallization can be seen under the microscope and softening is probably a combination of recovery and recrystallization. The boundary between these stages was fixed at almost identical times by all the methods of investigation.

Just previous to the second stage, an anomalous drop in conductivity sometimes occurs, which may be due to nucleation. A second conductivity anomaly is also observed, which may be explained by grain growth of new crystals in a softened but not completely recrystallized matrix. For lower degrees of reduction, evidence is advanced to show that grain growth can occur before recrystallization.

The temperatures used were well below those used for strain annealing and also below those at which so-called "abnormal" grain sizes are produced. As was expected from the results of previous investigators, the time required for beginning of recrystallization increased with increasing grain size, decreasing amounts of cold work, and decreasing temperature. JLG (2b)

Cleaning and Finishing Zinc-Base Die Castings

A Composite

Zinc alloy die castings, in general, now present no more difficult finishing problems than do other alloys or other metal-forms. They are usually smooth-surfaced to begin with, require only slight buffing before plating, are readily electroplated, if desired, and can be finished with any one of several organic coatings. Some of the latest developments are reviewed in three recently published articles.

As a base for finishing treatments, E. E. Halls ("Enamelling Zinc Alloy Die-Castings," *Ind. Chemist*, Vol. 15, Dec. 1939, pp. 433-436, 443) claims chemical pretreatments to be indispensable. Two such chemical treatments are used—phosphatizing and chromatizing. The "Parker PZ" and the "Granodine" processes are said to be the most widely adopted of the phosphate treatments. In the chromate treatment, the active solution is usually 34 oz. sodium dichromate and 3 oz. sulphuric acid per gal. of water.

One chromate treatment extensively used consists of degreasing with trichlorethylene (badly corroded or tarnished articles are immersed 1-2 min. in a boiling solution of chromic acid, 30 oz. per gal., followed by two cold water washes) followed by alkali cleaning and then by hot and cold wash. The work is then immersed for 5-15 sec. at 65°-80° F. in the chromate solution mentioned in the previous paragraph. After the chromate immersion, the work is washed in cold water, and dried cold, heat being rigorously avoided.

The chromated work is allowed to age at least 18 hrs. prior to painting or enamelling. Tests covering both cellulose and baked enamels show that in all cases the finishes on die castings without either mechanical or chemical pretreatment were unsatisfactory and that shot blasting delayed deterioration but did not prove reliable. The phosphated pretreatment resulted in entirely satisfactory results, and chromate pretreatment gave results superior to the phosphate. In practice phosphatizing is favored because it is more easily controlled.

Modification in pre-cleaning practice to reduce "copper blistering" of plated zinc-base die castings were successfully sought by E. A. Anderson & C. E. Reinhard of New Jersey Zinc Co. ("Alkaline Cleaning and Copper Blistering," *Mo. Rev. Am. Electroplaters' Soc.*, Vol. 27, Mar. 1940, pp. 175-183). Zinc alloy die castings are usually given a preliminary coating of copper, 0.0002-0.0003 in. thick, and then a nickel and a chromium coating. When the plated objects are coated with organic finishes and baked at 300° F., blistering of the electrodeposit frequently occurs.

Microscopic and X-ray examinations showed that the zinc and copper formed a diffusion layer which contained the brittle, zinc-rich epsilon and gamma alloys. The brittleness of these diffusion-layer alloys is responsible for the blistering. The amount of alloying between the zinc and copper was reduced by buffing the die casting before plating and by decreasing the length of time the die casting was in the alkaline cleaner. As an alternative, the strength of the cleaner could be reduced.

By suitably changing the cleaning procedure of some plants, rejections were decreased below 1%, whereas previously they had been as high as 25%. No explanation was given as to why the change in the cleaning procedure should decrease the alloying of the copper coating with the die casting.

Operating conditions for electrolytically stripping copper coatings from zinc die castings are described by W. B. Stoddard, Jr. ("Electrolytic Stripping of Copper from Zinc-Base Die Castings," *Trans. Electrochem. Soc.*, Vol. 77, 1940; Preprint No. 22, 3 pp.) Copper is removed from zinc by using 50-60 cycle a.c. in an electrolyte containing 200-500 gm./l. CrO_3 and 2-5 gm./l. sulphuric acid. The operating conditions are: Temperature, 68°-77° F.; current density, 7-14 amps./dm.^{2} Fifteen-20 min. are required to remove 8-10 microns (0.0003-0.0004 in.) of copper.

The operating conditions are rather critical. Below 68° F. copper strips slowly and above 85° F. etching of the zinc may result. Below the minimum current density zinc does not remain passive, and above the maximum current density both metals become passive. After the copper is stripped, the zinc is passive. The passivity is removed by dipping the die casting in dilute hydrochloric acid (10 cc. concentrated acid in a liter of water). X (2b)

Bright Silver-Plating Baths

Improved Silver-Plating Baths ("Verbesserte Silberbäder") R. Liebetanz. *Oberflächentech.*, Vol. 17, Feb. 20, 1940, p. 25. Descriptive.

The usual addition of carbon disulphide to potassium cyanide silver-plating baths gives bright silver deposits only with very thin deposits. Thicker deposits require subsequent polishing; furthermore, the volatility of carbon disulphide often results in non-uniformity of deposits. For very bright deposits even of great thickness, and without any subsequent treatment, additions of the derivates of thiol-carbamic acid are recommended.

The following bath compositions are given preference:

Constituent	Amount, g./l.		
Silver Cyanide	25	25	25
Potassium cyanide	45	50	45
Potassium carbonate	20	50	20
Potassium thiocyanate			20
Thio-urea or acetyl thio-urea	45		
Monomethyl-ammonium salt of monomethyl-thiolthiono-carbamic acid		0.5	

The baths should operate at 80° F. with a current density of 0.6 amp./dm.,^{2} and should be "aged" 2-3 days before use. In place of the two last named additions, thio-semicarbazide or the dimethyl- or monoethyl-ammonium salts of dimethyl- or monoethyl-thiolthiono-carbonic acid (respectively) and similar substances can be used with equally good results. Ha (2b)

Welding Copper

"Welding of Copper." A. P. Young (Mich. College Mining & Tech.) *Welding J., N. Y.*, Vol. 19, Jan. 1940, pp. 1-s—8-s. Investigation.

The factors that control successful welding of copper by either the oxyacetylene or the long-carbon-arc method were studied. Two series of welds were made on copper plate. The first series included 2 welds on plate ¼ in. thick, 4 on plate 5/16 in. thick and 3 on plate ½ in. thick, all made by the oxyacetylene welding process. The second series consisted of 6 welds on 5/16 in. and 8 welds on ½ in. plate, all by the long-carbon-arc process.

The welds made by the oxyacetylene process were good when made with a low-tin phosphor-bronze rod. The low strength welds obtained otherwise may have been due to improper operation of the torch, but not all the porosity could be attributed to this factor. A molten weld pool which wets the surface of the "V" does not indicate that a fusion weld has been completed; the wetting may be due to the running of the metal along the flux on the surface.

Two torches can be used to increase the speed of welding; the helper can weave the preheating torch in close proximity to the weld pool so that the bottom of the "V" will reach molten temperature at the same time that the top of the groove is fused, and thus complete a fusion bond. The direction of the flames should be such that their combined blast does not build up a high back wave and produce a heavy reinforcement on the top bead.

Heat can be saved and the welding speed increased by placing insulating, flame-resisting material over the plates and also between the plates and the backing bar or welding table. By means of preheating, the plate should be brought to a full red heat before welding is attempted, and the section of the plate just in front of the weld pools should be kept at that heat. A coating of flux on the rod is essential in maintaining a clean surface on the weld pool.

In the second series of welds, made by the long-carbon-arc process, a welder of large capacity was used and the plates were clamped to a copper backing bar. The tests showed that high voltages are essential for satisfactory welding, especially where copper backing bars are used. A special bar or block should be used to blank the under side of the double "V" when the first pass is made on the plate.

The welding speeds for ½-in. copper plate prepared with a double "V" should be 14-16 in./min. with high voltages. Higher speeds result in incomplete penetration. The welding speeds for 5/16 in. copper plate having a single "V" should be 11-13 in./min.

A high-tin (10%) phosphor-bronze rod gives best results, although successful welds may be accomplished with medium-tin phosphor-bronze, if the strength of the plate is not important. If it is possible to follow the first bead on a double "V" with the second bead before the heat of the first weld has been dissipated, better welds will result. Welding heats from the long-carbon-arc can be expected to travel laterally 1½ to 2 in. with annealing effect. To compensate for this, the thickness must be increased if strength is a factor.

The spacing of the plates before welding should be such that the inner edges of the "V" will be just short of touching after the welding heat has expanded the metal. Plates thicker than 5/16 in. should be beveled for a double "V" unless it is not possible to complete a second pass on the back of the plate. Graphite electrodes should be used in preference to the hard carbon electrode. CEJ (2b)

Finishing Magnesium Alloys

A Composite

Suitable protection of magnesium alloy products against corrosion is essential in practically every application of this light metal. Except for one or two moderately successful anodic oxidation processes (described below), electrolytic surface treatments are not generally applied. Chemical treatments, followed usually by painting, are in wide use. Methods for pretreating and finishing magnesium alloys are reviewed in two recent articles.

According to E. E. HALLS ("Protection of Magnesium Alloy Components," *Ind. Chemist*, Vol. 16, Jan. 1940, pp. 3-6), the use of organic finishes entails proper chemical pretreatment and careful choice of primer. Vapor degreasing may be used, but aqueous alkaline methods are more suitable since cleaning is followed by aqueous pretreatment. Surface corrosion products may be removed by judicious immersion in dilute (1-10%) sulphuric acid, although sand blasting or wire brushing is preferred.

The established chemical pretreatments require chromate solutions and are classified as (1) rapid, removing up to 0.003 in. of surface, and (2) slow, in which dissolution of base metal is negligible. Two generally used rapid solutions contain (a) 1½ lbs. commercial sodium dichromate and 1½ pints nitric acid (1.42 sp. gr.) per gal., and (b) 1 lb. chromic acid and 0.9 pint nitric acid. Both are operated cold with an immersion time of ¼ to 2 min.

Three solutions for slow pretreatment are given. One contains 16 oz. each of sodium dichromate and monobasic sodium phosphate, and gives a gray to black coating after 15-20 min. immersion just below the boiling point. The second contains 4 oz. each of sodium dichromate and ammonium sulphate and ⅓ fluid oz. of ammonia, and gives a dark gray coating after 20-30 min. in a boiling solution. The third contains 8 oz. each of sodium dichromate and potassium dichromate and gives a grayish coating after 1-2 hrs. in a gently boiling solution. A special red oxide or zinc chromate primer is generally used.

A series of tests with unpretreated and pretreated samples (using both the "rapid" and "slow" methods) were finished with cellulose and baked synthetic enamels. Both primed and unprimed specimens were made up in each case. Samples were exposed to salt spray and cyclic humidity exposure tests. Pretreatment by either method was of the same order of effectiveness. Pretreatment not only delayed initial attack but retarded the rate of deterioration. Priming in conjunction with pretreatment further enhanced corrosion resistance.

These and other surface treatments for magnesium alloys are discussed by E. WERNER ("Die Oberflächenbehandlung von Magnesium und seinen Legierungen," *Oberflächentech.*, Vol. 17, Mar. 5, 1940, pp. 33-34). For simple chemical treatment, a cold solution of 200 gm. of aluminum nitrate in 1 liter of water produces a well-adhering, matte-white oxide layer. The same solution, boiling, produces a yellow color after about 10 min. Dipping in a cold solution of 40 gm. sodium dichromate and 140 cc. hydrochloric acid in 1 liter of water gives a black finish; 80 gm. of sodium dichromate, 35 gm. copper sulphate and 10 gm. concentrated nitric acid in 1 liter of water gives a light olive green; 35 gm. sodium dichromate, 7 gm. iron nitrate and 1 cc. concentrated nitric acid in 1 liter of water, cold, gives a brass-yellow color. A yellowish-white, well-adhering layer is produced by a hot bath of 20 gm. nickel nitrate and 10 cc. concentrated nitric acid in 1 liter of water.

For anodic oxidation, acid baths as used with aluminum alloys cannot be used, as magnesium is too strongly attacked. Alkaline solutions work at high bath temperatures and low voltage, but the oxide formed is very soft and lacks the abrasion resistance of the aluminum oxides. Alkaline solutions with additions of sodium silicate and certain hydrocarbon derivatives give satisfactory oxide layers with 5 v. and 2.5-10 amps./dm.^{2}

Magnesium fluoride layers are produced electrolytically in a molten salt mixture of 65% potassium fluoride and 35% sodium fluoride at 35-40 v. and 2 amps./dm.^{2} after about 3 mm. The white-gray layers adhere firmly, and are uniform, but are highly porous so that they have to be subsequently coated with paint or lacquer. Selenium, arsenic, phosphate and molybdate compounds have not yet given completely satisfactory corrosion protection. The porous, electrolytically-produced protective layers can be improved by dipping in hot oil, paraffin, etc., or also in potassium silicate or sodium silicate, after the oxidized parts have been thoroughly dried.

[American practice is quite different, and evidently far more advanced than British and German methods, if these articles can be accepted as fairly representing the latter. The Dow Chemical Co.'s handbook and the Navy Dept.'s Bureau of Aeronautics Spec. No. SR101 are the best sources of information on finishing magnesium alloys.—H.S.R.] X (2b)

Grinding and Polishing Light Metals

"GRINDING, POLISHING AND BUFFING LIGHT ALLOYS." *Light Metals*, Vol. 2 Feb. 1940, pp. 54-55; Mar. 1940, pp. 80-83. Practical review.

Owing to the tendency of aluminum alloys to smear on the grinding wheel, high surface speeds of cutting are sometimes recommended on the assumption that more efficient cooling of the workpiece and the wheel is promoted. Naturally, however, the sliding sped between the two surfaces increases in the same ratio as the wheel speed. Nevertheless, cleaner cutting action seems to occur at higher speeds, and partly owing to the increased metal flow, better finishes are obtained. For rough polishing, slower speeds are more advantageous.

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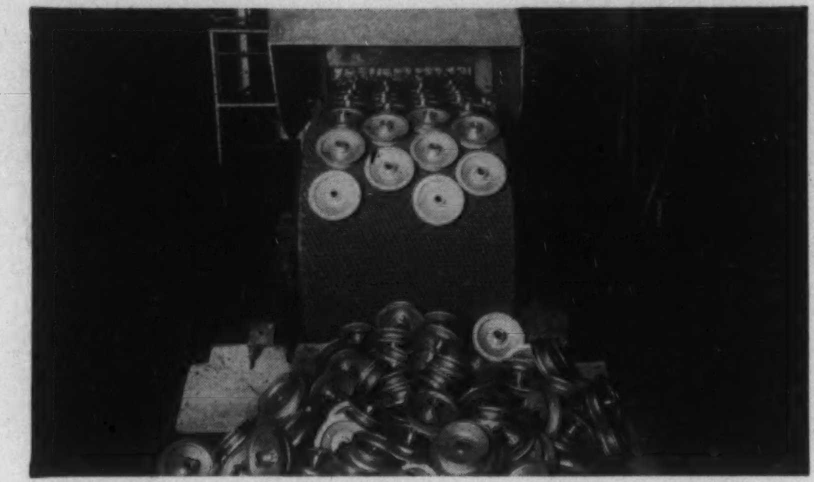

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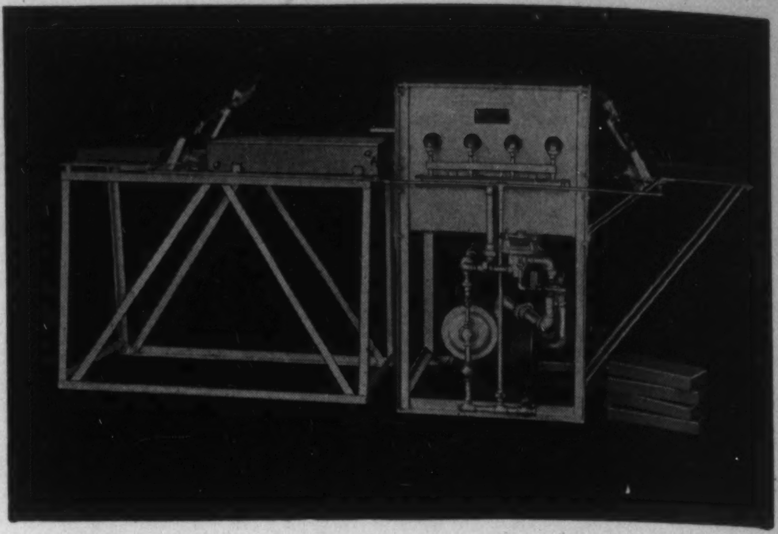

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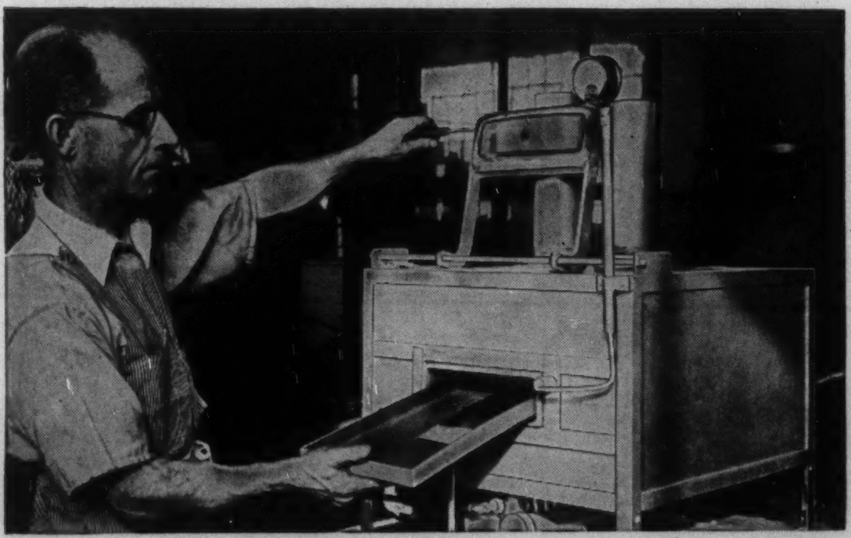

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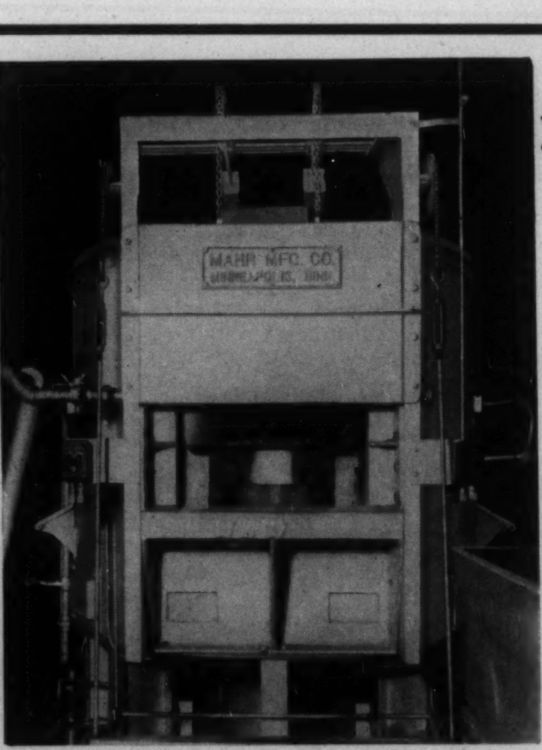

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readily than those of fused alumina, hence the tougher alumina wheels are recommended for tough materials like steel, and the more "free-cutting" silicon carbide has been recommended for light metals. However, the alumina wheels may prove to be more useful than silicon carbide in grinding the tougher aluminum alloys. It is necessary to choose grinding wheels for particular applications with reference to grit, grade (hardness), and structure (spacing) in order to obtain the best results. Wheels of open structure have been found to give best results with light alloys. This is in line with the large clearance angles used in machining aluminum alloys.

The circumferential speed of grinding wheels ordinarily varies from about 4,000 to 7,000 ft./min. There are, of course, numerous exceptions; for example, a speed of only 1,000 ft./min. is recommended by one authority for snagging large magnesium castings with a coarse-grained wheel. In general, with cylindrical grinding, the workpiece is rotated to give a surface speed of from 40 to 120 ft./min. The cutting depth may vary from 0.0012-0.0024 in. in roughing, to 0.0002-0.0004 in. for finishing. In connection with proper feeds, a rough rule is that in rough grinding, the feed per revolution should be over ⅔ the width of the grinding wheel, while in finishing, feeds from ½ to ⅔ the width of the wheel per revolution are recommended. The ratio of the weight of the grit removed to the weight of metal removed in the case of light metals ranges from 1:50 to 1:80, less than ½ the consumption in grinding cast iron.

Light metal pieces should not be ground with wheels that have been previously used for other materials; small particles of heavier metals are apt to cause scoring. Copper particles thus embedded in aluminum alloys may easily initiate serious corrosion, while iron particles in a wheel may cause a fire in grinding magnesium.

Aluminum alloys are generally ground wet, while magnesium is ground dry. Water-oil emulsions are frequently used in grinding aluminum; one function of the grinding fluid is to prevent penetration of the metal particles into the surface of the grinding wheels. Other mixtures employed are kerosene-spirit, lard oil and kerosene. The swarf formed when grinding magnesium is removed with a high-velocity air stream and immediately settled by water.

In free hand grinding, the wheel should be somewhat softer than that customarily used for iron and steel. If an equal amount of stock is to be removed from workpieces of aluminum and steel of the same size, the grain size of the wheel employed for the light metal should be coarser. In centerless grinding of light metal parts, the grinding wheel, grinding bars, and cutting fluid must be especially adapted for the material to be ground. When these precautions are taken, the same machine may be used for the grinding of both heavy and light metals.

For the centerless grinding of aluminum tubes, the following recommendations have been made: tube size, 1¼ in. by 3¾ in.; wall thickness ⅛ in.; grinding wheel dimensions 20 in. by 6 in.; silicon carbide, grain size 46, grade 1, spacing 5; wheel speed 1,250 r.p.m. (785 ft. per min.); feed wheel inclination ½ deg.; speed 12 r.p.m. With these instructions a commercial finish can be obtained to within limits of 0.0005 in., one pass removing 0.008 in. of stock, at a production rate of 160 pieces per hr., with the wheels dressed once a day.

In polishing light alloys, more care must be given to the process than in the case of polishing brass, for example, owing to the softness of the former. The abrasive numbers used for roughing range, as a rule, from 90 to 120; while for finishing, grades from 120 to a "flour" are used with wheels operating as high as 10,000 ft./min. Of possible types of roughing abrasive, the following 3 chiefly used materials are listed in descending order of hardness: silicon carbide, alumina, and emery.

In buffing, felt discs are preferred. Special buffing compounds are flours of tripoli, ochre (crocus or rouge) and viennese lime mixed with greases such as stearin, paraffin, beeswax, etc. For coarser polishing, these bonds may be mixed with alumina, emery powder, pumice, etc. The circumferential speed of buffing wheels usually varies between 7,200 and 11,000 ft./min. After considerable use, the buffing wheel may be trued with a sharp body such as the sawed edge of a steel bar. "Coloring" may be produced as a last step in the polishing operation to bring out the natural color of the alloy, and is carried out on the cleaned, polished surface with a buffing wheel, usually with no polishing medium. Speeds of 9,000 to 11,000 ft./min. are used.

A satin finish may be obtained on aluminum by means of a steel scratch brush, of not over 8-10 in.; the brush is operated at 3,750 to 4,000 ft./min. The wires in the brush should be kinked, and of a dia. not over 0.002 to 0.004 in.

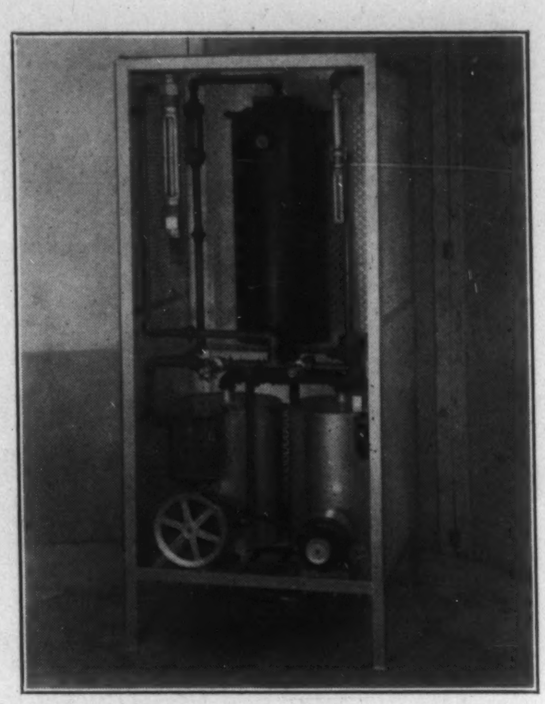
Grease on the surface of the workpiece should be avoided in producing a satin finish, as unsightly patches will result. Fibre brushes used in conjunction with oil and emery will produce a matte finish often desired in architectural work. To avoid a patchy surface in forming a matte finish on large surfaces a large brush should be used. Defective spots can later be touched up with a hand operation of rubbing with steel wool or worn emery cloth and turpentine.

Barrel polishing is well suited to the production of a large number of small pieces. It is recommended that the charge be degreased before it is put in the barrel, which rotates between 15 and 40 r.p.m. Before the pieces are charged into the barrel, it is necessary to remove all unwanted projections, usually with 180-240 grit. Either steel balls or an abrasive compound may be used in barrel polishing, depending upon the type of finish desired. The balls should fill approximately ¼ of the barrel and should not jump, but exert a rolling effect upon the pieces.

One author recommends the use of polished steel balls of 5/64 in. to ¼ in. dia. with a solution containing 1.1 lb. soap flakes and a little liquid ammonia and benzene in 6.6 gal. of water. The time required may vary from ½ to 2 hrs. After removal, the charge may be rinsed in water and barreled in warm sawdust. It is desirable completely to fill the barrel so that no great "segregation" of the steel and aluminum occurs, owing to the difference in specific gravity. A fine matte finish may be obtained by the use of a mixture of 4 parts sawdust and one part of pumice.

For faster action, a diatomaceous earth product (Celite) has been suggested. This material tends to produce a coarser finish than pumice, because unlike pumice, it does not break down readily into finer and finer particles.

Sand blasting may be used to produce a matte gray surface, but the hand must be carefully graded, and the blast pressure should be low, and well regulated. This method produces an excellent base for the application of paint or lacquer. Untreated, it is sensitive to staining and, if used for decorative purposes, must be protected by a transparent lacquer. AUS (2b)



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Modulus of Elasticity of Alloys

MODULUS OF ELASTICITY OF METALLIC ALLOYS ("Contribution a l'Étude du Module d'Élasticite des Alliages Métalliques") L. GUILLET, JR. *Rev. Mét.*, Vol. 36, Dec. 1939, pp. 497-521. Research.

Recognition of the practical importance of the modulus of elasticity is increasing daily. In this study, the modulus in tension was determined by the Rolland-Sorin pendulum method. The results of the tests on pure metals are given in the table. The modulus seems to be related to atomic volume; the higher modulus figures are obtained with elements having a low atomic volume and a high melting point. There is approximately a linear relationship between modulus of elasticity and the ratio of melting point to atomic volume squared.

Metal	Atomic volume	Melting point, °F. (approx.)	Modulus of elasticity, lbs./in.^{2}
Tungsten	9.6	6620	59,740,000
Beryllium	4.9	2330	51,200,000
Iron	7.1	2790	29,870,000
Nickel	6.6	2640	31,300,000
Platinum	9.1	3220	23,180,000
Copper	7.1	1980	17,920,000
Silicon	12.2	2590	13,510,000
Gold	10.2	1940	12,090,000
Zinc	9.2	790	11,380,000
Silver	10.2	1760	9,960,000
Aluminum	9.9	1220	10,380,000
Magnesium	13.9	1200	6,400,000
Tin	16.3	450	5,690,000
Calcium	26	1490	2,840,000
Lead	19	620	2,560,000

The solid solutions investigated (copper with up to 9.9% Al; copper with up to 37.3% Zn; copper with up to 9.9% Sn; platinum with up to 24.6% Ir; and platinum with up to 15.0% Rh) showed an approximately linear relationship between modulus and chemical composition (the greatest deviations were noted when the density of the two elements differed appreciably). The intermetallic compounds could be separated into two groups: (1) Those where the modulus agreed approximately with the law of mixtures; these had metallic characteristics, such as CuZn, Al_2Cu; and (2) those where the modulus was considerably higher than that indicated by the law of mixtures; these are the homopolar compounds with especially strong atomic bonds, Cu_9Al_4, Cu_5Zn_8, $Cu_{31}Sn_8$.

Alloys consisting of 2 phases (aluminum with up to 12.8% Cu; copper with up to 16.6% Be; aluminum with up to 11.9% Mg; magnesium with up to 12.1% Al; copper with up to 100% Al; copper with up to 100% Zn; and copper with up to 100% Sn) have modulus figures corresponding approximately to a linear relationship with chemical composition regardless of the nature of the two phases. (In the last 3 systems, the slope of the modulus-composition curve changes abruptly when the two phases change, *i.e.* an intermetallic compound is formed).

It therefore seems impossible to increase markedly the modulus of alloys by the addition of other alloying additions, even though the modulus of the elements added are high. By the same token, impurities will have but a negligible effect on the modulus. Unfortunately, the alloys containing intermetallic compounds and giving high modulus values are too brittle for general commercial use.

The effect of heat treatment was investigated in a number of alloys and it was found that the modulus may be decreased to as little as 40% of the as-annealed value by quenching alloys that undergo a transformation at high temperatures (copper with 9.9-15.7% Al; copper with 22-32% Sn; copper with 50.9-75.5% Au; copper with 2.5% Be; and aluminum with 0.8% Be). The decrease was not due to micro-cracks, since a subsequent anneal with slow cooling restored the modulus to approximately its original as-annealed figure. JZB (3)

3a. Ferrous

Steel Tubing— Seamless or Welded?

A Composite

The advantages of tubing as a metal-form competitive with solid shafts, bars, etc., are increasingly recognized by metallurgical engineers engaged in engineering design. Aircraft design depends heavily on steel tubing, and so much of this is of the seamless variety that we might easily lose sight of the true importance of welded tubing.

Airplane tubing is made in such light gages—between 0.065 and 0.035 in. wall thickness—that the influence of even slight imperfections is magnified ("Alloy Steel Tubes for Airplanes," *U. S. Steel News*, Vol. 5, Apr. 1940, pp. 20-21). The high stress at which tubes are employed in aircraft design requires the adherence to extremely rigid quality standards in their manufacture. For both these requirements seamless tubing is eminently suited.

Seamless alloy tubing as now manufactured has yield strength around 75,000 lbs./in.^{2}, tensile strength about 100,000 lbs./in.^{2}, and elongation 12% in 2 in. For a number of applications in highly-stressed parts, airplane tubes are given special heat treatments to develop tensile strengths as high as 180,000 lbs./in.^{2} In addition to round tubes, the industry employs numerous special shapes, such as squares, rectangles and streamline forms—all made from an originally round tube. Tapering of wall thickness is often used, to provide more advantageous distribution of load along the length of the tube—as in autogiro tubes and in certain wing strut tubes.

The applications of *welded* steel tubing in the automotive industry are discussed by G. C. GRIDLEY of Borg-Warner Corp. ("Welding Propeller Shaft Tubing for the Automotive Industry," *Welding J.*, N. Y., Vol. 19, Mar. 1940, pp. 195-200). Examination of the modern motor vehicle discloses welded tubing to be in use for exhaust pipes, torque tubes, steering columns, tie rods, brake rods, seat frames, and in numerous other places. Many of these parts were originally fabricated from solids or bars and others from seamless tubing, but at the present time welded tubing of one kind or another is utilized to a great extent.

One of the inherent difficulties with the use of seamless tubing for propeller shafts that required better balance characteristics was the once prevalent variation in wall thickness at various points on the diameter. Experiments to find some good method of overcoming this vibration difficulty proved not entirely successful. It was suggested, finally, that propeller shafts made from tubing welded from strip steel of uniform thickness would run with less vibration at higher speeds than shafts made from seamless tubing. Use was ultimately made of a small production lot of propeller shafts built with gas-welded tubes which, as far as could be learned, proved entirely successful in the field.

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The original specification for material was for S.A.E. No. 1010 steel, cold-rolled to three-quarter hard temper (70-80 Rockwell B) of the rimmed or semi-killed variety. A change to S.A.E. No. 1010 silicon-killed steel, rolled to the same temper, improved the weldability greatly. As a result of the increase in torsional requirements, carbon and manganese contents for the strip were raised along with the hardness, and the most recent specification calls for strip steel corresponding to S.A.E. No. 1020 with the carbon content about 0.20% and the manganese toward the upper limit of the range, approximately 0.60%. This steel is processed to full hard temper at the mill with a hardness of 85-100 Rockwell B. So far, this material has demonstrated its ability to be welded satisfactorily at higher speeds. X (3a)

Creep of Steels

"Creep at High Temperatures." H. J. Tapsell. *N. E. Coast Instn. Engrs. & Shipbuilders,* Adv. Copy, Feb. 1940, 20 pp. Survey.

Creep characteristics of metals are reviewed, with particular attention to the behavior of carbon and molybdenum steels for superheated steam temperatures. A parallel is drawn between the properties of soft metals at room temperature and steels at high temperatures.

Rapid loading and unloading, in general, gives the appearance of elastic behavior, while longer time at the same stresses may cause permanent deformation. Therefore, it is not unusual for slow creep to occur at high temperatures with stresses below the "limit of proportionality" determined by a tensile test at that temperature. Likewise, the modulus of elasticity at high temperatures is less for step-by-step loading than when measured by the vibration frequency method, because of the undetected creep in the former method. There is as yet no comparatively rapid method of test for satisfactorily determining creep at high temperatures.

For a carbon steel, the duration of the first stage (creep decreasing with time) diminishes as the temperature is increased, in proportion to the total time for fracture; also, the amount of deformation during this stage decreases in proportion to the total deformation. It is noted that a creep rate of 1 x 10^{-7} in./in./hr. may appear to be inappreciable, but would result in a total deformation of 1% over a period of a year. The variation of creep rate with temperature, stress and time is discussed for various ferrous and non-ferrous metals; some of the data are summarized in the table.

Creep Strengths of Some Metals

Material	Temperature, °F.	Approximate stresses (lbs./in.^{2}) for creep rates, at 1,000 hrs., of:		
		4 x 10^{-7} per hr.	4 x 10^{-6} per hr.	4 x 10^{-5} per hr.
0.39% C forged steel	950	13,000	16,300	19,000
0.3% C cast steel	950	8,500	11,800	15,200
Ni-Cr steel (hardened and tempered)	850	7,800	14,500	22,500
13% Cr stainless steel (hardened and tempered)	850	23,500	33,500	41,500
1.7% Mn steel	850	23,500	27,000	35,500
Duralumin	500	5,500	7,400	8,700
Phosphor bronze	500	10,000	15,800	21,000
60 : 40 brass	500	1,100	2,700	5,600

Data on the variation of creep rate with temperature, at a constant stress of 10,000 lbs./in.^{2} show that the extra creep resulting from a rise of 35° F. above normal working temperature during a period of service is not compensated for by a similar period 35° F. below the working temperature. It is also noted that similar rapid increases in creep rate with temperature occur at lower stresses than that of 10,000 lbs./in.^{2} used in these tests.

A number of carbon steels made by different processes were tested in the normalized condition for creep rate (at 5 days) at 850° F. and 17,000 lbs./in.^{2} stress. There was no real correlation, the data showing that it is possible to obtain carbon steels of relatively poor creep resistance by any one of the three manufacturing processes tested (acid open hearth, basic open hearth, basic electric). Also, just as good creep resistance at 850° F. is obtainable with 0.16% C steels as with 0.25 or 0.40% C steels. With these same steels, poor creep resistance at 850° F. was accompanied by poor creep resistance at 750° F. and at 1025° F., and for lower stresses than 17,000 lbs./in.^{2} The creep rate is most sensitive to very small differences in the constitution and structural condition of two otherwise similar steels, so that creep rates in the ratio of say 2:1 may signify very little real difference in strength. A small change in stress, or difference in temperature in one steel may bring the creep rates into line with each other.

Tests made on carbon-molybdenum steels indicate that low-carbon is advantageous in both 0.50% and 1% Mo steels. Also, 0.80% or 1% Mo gives somewhat better results than 0.5% Mo. The addition of a small vanadium content to the molybdenum steel gives further improvement.

A spheroidized structure in carbon and carbon-molybdenum steels results in reduced creep resistance. The spheroidized 0.10% to 0.15% C steel has the same creep strength at a given (high) temperature as a normalized material subjected to a temperature 35° F. higher. For the 0.40% C steel the difference is about 50° F. A 0.11% C, 0.52% Mo steel heated at 1155° F. for 14 days to give partial spheroidization had a creep rate, at 1025° F. and a stress of 20,000 lbs./in.^{2}, 80 times greater than the same material in the quenched-and-drawn condition. Some improvement in creep resistance has been noted for carbon-molybdenum steel heated during service to 800°-900° F.; even at 1,000° F. the first effect is an improvement lasting several months, until spheroidization begins.

Cast carbon and carbon-molybdenum steels are inferior to wrought steels only at lower temperatures; at 1,000° F. this difference practically vanishes. The quantitative effect of grain size is difficult to assess because of marked structural differences coexisting with differences in grain size. This was well exemplified by one 0.40% C steel that had been coarsened at 2,000° F. before normalizing, and then showed improved creep at 850° F. as compared with the ordinary normalized material; another such steel similarly treated showed the reverse behavior.

Discussing the estimation of working stresses, the author considers invalid the published assumption that the second stage of creep is reached within 1,000 hrs. and that the creep rate in the second stage may be considered to remain constant during a service life of 10,000 or 100,000 hrs. The data are expressed as stresses for 0.1% creep in 1,000, 10,000 or 100,000 hrs., but actually the stresses are those corresponding to creep rates ranging between 10^{-6} and 10^{-8} at 1,000 hrs. A more rational method of estimating working stresses would be a determination of actual times for the creep deformation to reach 0.1% from a series of creep tests at different stresses and extrapolating the curve of log of actual time *vs.* log of stresses to 100,000 hrs.

One method of plotting suggested by Bailey has considerable merit in dealing with the wide variation in creep properties of carbon steels of similar composition. The curves are plotted as ratio of stress at higher temperatures to stress at 750° F. (in per cent) *vs.* temperature. Several such curves may be plotted for 0.1% in 1,000 hrs., 0.1% in 10,000 hrs. and 0.1% in 100,000 hrs. This method, although referring to 0.1% creep, is reasonably applicable for 0.2% and possibly 0.3% creep in the times stated. Thus, from a knowledge of working stresses suitable for any temperature, say 750° or 800° F., it is possible to calculate suitable stresses for higher temperatures.

Examination of fractured molybdenum steel creep specimens revealed inter-crystalline cracking irrespective of the condition of the steel (*i.e.* as-rolled, normalized, hardened-and-tempered, etc.), but this cracking will not take place until at least 1% deformation has occurred. Therefore, a specification of a permissible deformation of 0.1 to 0.3% should be entirely safe for service. WB (3a)

Low-Alloy Manganese Steels

Manganese Carburizing Steels with Additions of Chromium, Silicon or Vanadium and a Minimum of Imported Elements ("Sparstoffarme Manganeinsatzstähle mit Zusätzen von Chrom, Silizium oder Vanadin") H. Schrader & F. Brühl. *Tech. Mitt. Krupp, Forsch. Ber.,* Vol. 2, Dec. 1939, pp. 207-215. Manganese Oil-Hardening Steels with Additions of Silicon, Chromium or Vanadium but Poor in Imported Elements, and Their Success in Practice ("Sparstoffarme Mangan-Vergütungsstähle mit Zusätzen von Silizium, Chrom oder Vanadin und ihre Bewährung in der Praxis") H. Kallen & F. Meyer. *Ibid.,* pp. 215-222. Review plus research.

Developments in the last few years in the alloy steels field reveal a tendency to abandon the more highly alloyed steels in favor of simpler steels. This tendency in Germany was the result of attempts to avoid the use of alloying elements that had to be imported, such as nickel and molybdenum; the same trend developed in America because the improvement in steel quality through the use of alloying elements was often considered not to be in proportion to the greater expense in manufacture and special treatment required.

Unalloyed case-hardening steels of small sections can be produced with higher core strength by increasing the carbon content; if about 0.40% Mn is present, a core tensile strength of 190,000-200,000 lbs./in.^{2} in ¼-½ in. stock would be obtained with 0.22% C after hardening from 1500° F.; with 0.60% Mn, 0.16-0.20% C would suffice. For greater thicknesses, however, manganese steels of at least 2% Mn and 0.15-0.19% C would have to be used, and these are fairly sensitive to over heating.

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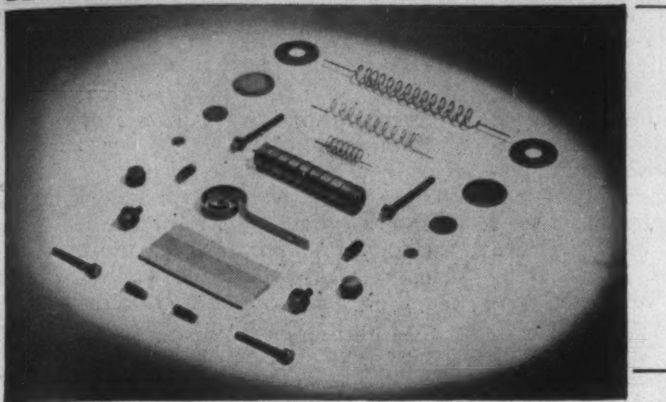

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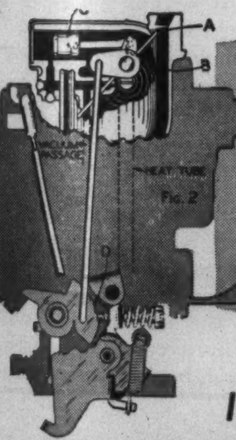

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In such cases it is better to employ manganese-silicon steels (about 1.5-1.8% Mn, 1.5% Si and 0.15-0.20% C) but these in larger sections have tensile strengths less than 110,000 lbs./in. when hardened in oil.

If, instead of the increased silicon addition, chromium be added to manganese steels to increase hardenability, the chromium content should not exceed 1.8%; higher contents have a tendency to cause marginal carbide formation during carburization. Small additions of vanadium to manganese steels increase grain fineness, improve toughness and reduce the sensitivity to overheating. As vanadium is expensive, only small amounts are used.

The best oil-hardening manganese steels are those with additions of silicon, chromium and vanadium; the depth-hardening, however, is somewhat less than with chromium-molybdenum grades. A manganese steel containing 0.32-0.35% C and 0.20-0.35 Si showed with increasing manganese content an improved ratio of elastic limit to tensile strength for hardening at 1500°-1550° F. in oil. Manganese-silicon steels with up to 1% Si and 1.2-1.5 Mn, hardened at 1550° F. in oil, can easily be forged and are suitable for turbine and compressor shafts. The addition of chromium to manganese steels improves depth-hardening and gives a high ratio of elastic limit to tensile strength. A small addition of vanadium to the oil-hardening manganese steels has an even better effect than in the case-hardening steels.

For nearly every purpose in industry a manganese steel with additions of silicon, chromium and vanadium can be found that, if properly heat-treated, will possess high elastic limit and tensile strength, and good values of elongation, reduction of area and notch-toughness. Ha (3a)

Engineering Design with Iron Castings

A Composite

Engineering designers attempting to evaluate available metals and metal-forms for heavy machinery look with favor on the sturdiness of cast iron structures, the high damping capacity and machinability of the material, and the truly competitive mechanical properties of modern irons. Other service factors, not always considered by the designer, are discussed in several recent articles on internal stresses in iron castings, and on service stresses they must resist.

Iron castings nearly always contain internal stresses, points out A. LE THOMAS ("Fontes Stabilisees," *La Fonte*, No. 6, Nov./Dec. 1939, pp. 226-232; translated in *Foundry Trade J.*, Vol. 62, Mar. 21, 1940, pp. 217-218, 232). These forces, sometimes powerful enough to cause spontaneous rupture, result from contractional differences to which various portions of the same castings are subjected. The stronger the iron, the greater the tendency to break through inverse contraction, because the strongest irons are those possessing the highest modulus of elasticity and the highest contraction.

Stress relief can be obtained by heating castings to about 1200° F. and allowing them to cool slowly. The tensile strength of cast iron is somewhat lowered by this treatment, and an iron with a Brinell hardness of 250 as-cast would, after the stress-relieving process, be about 180. The removal of casting skin also is said to reduce considerably the internal stresses.

An opposite viewpoint—that neither stress-relief stabilizing nor annealing entirely eliminates stresses, but that quenching followed by suitable tempering does—is expressed in an extended review of internal stresses in cast iron published by J. E. HURST ("An Investigation of the Internal Stresses in Cast Iron," *Iron & Steel*, Vol. 13, Oct. 1939, pp. 29-32; Nov. 1939, pp. 61-64; Jan. 1940, pp. 133-134). A method of calculating the internal stresses in cast iron piston rings and cylinder liners is also explained.

The method comprises measuring the amount of movement of a gap cut in rings machined from the casting being examined. The dimensions of the test ring are accurately measured, the ring is clamped rigidly in a vise, the gap carefully cut, and the ring is then released from the vise and the movement of the rings in either closing or opening the gap is measured—opening indicating tensile stress, and closing compressive. Absence of gap movement does not necessarily mean absence of internal stresses, since these may be present in such form that the sum of the stresses and couples across any plane is zero—a very rare condition, however.

Considerable errors were shown to be possible if commonly accepted values for modulus of elasticity are employed in calculating the stress values. And in machine-tool design the modulus of elasticity is more important even than tensile strength, says P. A. RUSSELL ("Cast Iron and Its Relation to Machine Tools," *Foundry Trade J.*, Vol. 62, Mar. 1940, pp. 205-207). Ultimate tensile strength is of little importance in most machines as the sections required to obtain a rigid structure are such that failure by fracture is rare. In fact, the ordinary transverse test as used for cast iron may be a more useful guide than the tensile test; the designer tries to keep his major stresses compressive, but bending stresses do occur. Irons with tensile strengths of 30,000-40,000 lbs./in.^{2} should meet every demand except for parts carrying exceptional stresses. For these cases tensile strengths of 40,000-60,000 lbs./in.^{2} are available in special cast irons like Ni-Tensyl or the higher grades of Meehanite.

The modulus of elasticity plays a great part in rigidity; the higher the modulus the less deflection under a given load. The modulus does not increase in direct proportion to the tensile strength, and rises from 11×10^{-6} for the weakest iron to about 20×10^{-6} for the stronger irons. The increase of modulus tends to reduce the capacity of cast iron for damping out vibrations. It is usually necessary, therefore, to compromise between high modulus of elasticity and low tendency to vibration.

Heat treatments that produce great improvement in the dynamic properties required to resist ordinary stresses may effect only slight improvement in resistance to single heavy impacts, according to E. PIWOWARSKY ("Beitrag zur Schlag-und Ermüdungsfestigkeit von Hochwertigem Grauguss," *Giesserei*, Vol. 27, Feb. 23, 1940, pp. 59-61), who discusses impact and fatigue strengths of "high-test" iron. Designers should bear in mind, too, that it is unsafe to draw conclusions about the behavior of an iron under repeated light impacts from the conventional impact strength as determined from single-impact tests.

X (3a)

Steel Castings in Weld-Design

"USE OF STEEL CASTINGS AND ROLLED STEEL PLATE IN WELDED FABRICATION." H. J. SHIFFLI & E. L. KREJCI (Am. Steel Foundries) *Welding J., N. Y.*, Vol. 19, Mar. 1940, pp. 173-177. Practical.

One of the chief advantages of welded construction is that it allows the designer to use in combination a variety of shapes and metal-forms of steel to produce the best design at a minimum cost. The welding art is immensely broadened by the application of steel castings as integral parts of welded structures.

When a particular part of a fabricated structure is intricate and does not lend itself to simplification by the use of standard shapes and forms, the designer should consider a steel casting. Intricacy, compactness, quantity, direct labor, costly equipment and varied materials are deciding factors in determining "when and where" to use steel castings in welded fabrications. A long and rangy structure with thin walls and simple physical characteristics should never be made as a single steel casting. Such a structure is inherently a welded fabrication.

In a broad sense, effective fabricated design will frequently include steel castings and forgings as well as rolled plate and standard shapes. By the use of the proper material or a suitable combination of materials, a balanced structure can be designed and built, which in its completed form will best serve the purpose for which it is intended. CEJ (3a)

Resting Fatigued Steel

INFLUENCE OF REST PERIODS ON THE ENDURANCE OF ALTERNATELY STRESSED PARTS ("Beeinflussung der Lebensdauer wechselbeanspruchter Teile durch Ruhepausen") K. DAEVES, E. GEROLD & E. H. SCHULZ. *Stahl u. Eisen,* Vol. 60, Feb. 1, 1940, pp. 100-103. Research.

In the experiments described the specimens were "overstressed", *i.e.* stressed appreciably above the endurance limit. When the overstresses were applied continuously, the number of reversals withstood was considerably lower than when a "rest period" intervened before the stresses were continued again.

This "healing" effect of the rest period was greater when it occurred after fewer stress applications. A 3-day rest period gave greater improvement than a ½-day rest period. After too large a number of overstresses, a rest period did no good. Presumably by this time actual cracks had begun to form and it was too late for the rest period to have its healing effect.

The samples tested were 0.7-0.8% C, patented and cold-drawn steel wires. The increase in the number of stress reversals withstood after overstressing to 1-1/5 times the continuous endurance limit resting 3 days and then continuing, was over 25%. Samples containing free ferrite showed the greatest improvement.

In lower carbon steels (0.06 and 0.42% C) heating samples to 300° F. for 5-10 min. and slow cooling after stressing to about 1-1/12 times the continuous endurance limit gave an improvement of as much as 200% in the number of overstresses withstood. SE (3a)

Electrical Steel Sheet

"STEELS FOR ELECTRICAL PURPOSES." E. MARKS. *Sheet Metal Ind.*, Vol. 14, Mar. 1940, pp. 265-268. Review.

Electrical sheets are of prime importance not only for wireless and remote control gear, but also for electrical gear to explode magnetic mines at a safe distance from the ship. Electrical sheets must be capable of forming easily and have a fairly high yield point (for some applications).

Often power loss is more important than permeability for a. c. equipment; ingot iron may give a core loss of more than 6 times that of silicon steel sheet. As the silicon increases from 0.2 to 4.4%, the maximum total loss in watts/kilo at $B_m =$ 10,000 and 50 cycles for the usual gages (0.014-0.020 in.) decreases gradually from 3.35 to 1.10. The better total loss of the higher-silicon sheets is due partly to their higher purity, as they are melted in electric arc furnaces and have consequently lower sulphur (0.002% as compared with 0.03% for open hearth steel). It is well known that sulphur and carbon, especially, are detrimental to hysteresis loss.

Silicon sheet can not be rolled in strip mills because of the brittleness of the higher-silicon alloys and the difficulty of producing the proper grain structure in the lower silicon alloys; therefore, the sheet is rolled in packs in 2- or 3-high hot mills. The larger the grain size, the better the permeability, but with large grain size more trouble is encountered in shearing and in use, so a compromise grain size must be selected and accurately controlled. This grain size can be somewhat larger for the higher-silicon than for the lower-silicon.

Ordinary electrical sheets are annealed in a radiant tube furnace fired with washed producer gas, while very low-loss sheets are annealed in hydrogen atmospheres in electric furnaces; the temperature in both cases must be closely controlled by thermocouples in various parts of the load. JZB (3a)

3b. Non-Ferrous

Copper for Underground Pipe

"The Resistance of Copper to Soil Corrosion." H. G. Taylor. *Engineer*, Vol. 169, Feb. 16, 1940, pp. 156-158; Feb. 23, 1940, pp. 176-178. General review of tests in England and America.

Convincing evidence of the resistance of copper to soil corrosion is available in the condition of an article found below the level of clay left by the Great Flood in Mesopotamia, said to date back to 4000 B.C. Soil characteristics that have a bearing on copper corrosion are pH, amount of moisture, total acidity or alkalinity, nature and concentration of salts present, grain size, aeration of soil and its electrical resistivity.

Differential aeration, an important cause of corrosion of ferrous metals, is of less importance with copper. Contact with two different kinds of soils, or cinders, which set up differences in electrical potentials between any two points on the surface of the metal, is an important cause of corrosion. Copper is susceptible to sulphide corrosion, which arises from cinders, decayed vegetation or sewage.

Corrosion data may be obtained from: records of actual experience, laboratory-scale tests in which metals are buried in soil, and field tests. From field tests the National Bureau of Standards concludes that (1) Soils differ greatly in corrosiveness. (2) Rates of corrosion differ with period of exposure. (3) The depth of the deepest pit on a corroded area is a function of the area exposed. (4) The relative corrodibility of different metals varies according to the type of soil. (5) There is no close relation between rates of corrosion based on weight losses and those calculated from depth of pit. (6) Under uniform conditions, the rates of corrosion of two specimens of the same material may differ.

Tests of 1½ to 8½ yrs. duration show that in no case, except when the soil was composed of cinders, was there more than a green coating on copper, whereas other metals were slightly pitted and in some cases, in bad condition. Accelerated corrosion tests conducted in California on the relative life of copper and steel pipes in extreme types of soils indicated that the corrosion of steel (expressed as loss of weight) is from 13 to 30 times greater than copper. The corrosion of steel expressed as maximum pit is from 74 to 250 times greater than copper. Therefore, the corrosion of copper is not only less, but is much more uniform than steel.

The National Bureau of Standard's soil corrosion investigation began in 1911, and since then about 15,000 specimens have been buried over a period of years—from 8 to 12 yrs. in any individual case. Many have been unearthed and their corrosion determined. Thirty-one different copper-base materials were tested, varying from 99.97% pure copper to Muntz metal, 60% Cu and 40% Zn. On the average, the corrosion of ferrous materials is 15.6 times that of copper specimens; in 6 cases out of 31 it was over 30 times that of copper and in one case as high as 52 times. In very few cases was the rate less than 4 times.

As a general rule, the corrosion of copper alloys was greater than that of plain copper. Though the alloys are used in valves, clamps, etc., the thickness of metal is greater than that of pipe, and therefore the larger corrosion rate is permissible. Data on the weight loss and penetration of various metals and alloys exposed to 5 different soils for 10 yrs. show an average corrosion rate for copper of 0.048 oz./ft.^{2}/yr.; for lead, 0.088; for zinc, 0.297; and for iron and steel, 0.67.

The Bureau concludes that copper and high-copper alloys are corroded slowly in moist soils. The rates of corrosion of all copper alloys were higher in cinders than in any type of soil. The corrosion of copper and high-copper alloys was more nearly uniform over the surface than that of ferrous material in most soils. Muntz metal, which is dezincified in a number of soils, should not be exposed to severe soil conditions. Rates of copper and brass corrosion changed less with time than did the corresponding rates for ferrous materials. Recent experience with buried copper pipes of some American gas companies has shown substantial savings to be possible because of the reduction of the cost of digging-up to replace corroded pipes.

It is a known fact that when two different metals are in contact in the presence of an electrolyte, a current flows between them resulting in accelerated corrosion of the "anodic" metal, and reduced corrosion of the "cathodic" metal. Therefore, corrosion may occur when copper pipe is connected to iron or steel pipe. Connection of copper pipe to a *coated* steel or cast iron may avoid the possibility of galvanic corrosion, but a few breaks or pinholes in the coating may spell trouble. Where a large area of copper is connected to coated steel or cast iron pipes having imperfections in their covering, accelerated corrosion will occur in the vicinity of the imperfections. When cast iron and steel pipes are connected directly to copper pipes underground, the former should not be protected unless protection can be ensured, or the thickness of pipes is such that corrosion, at a low rate, can be tolerated. VSP (3b)

Silver in Engineering

A Composite

If and when the United States' Silver Purchase Act of 1934 is repealed, the artificially-supported world price for silver may come tumbling down, with Heaven knows what effect on the value of the Government's fabulous silver hoard and on the silver market generally. Large-scale industrial use of silver would ease the situation appreciably, but that seems to be a long way off. However, there is certainly in progress a determined effort to find new engineering applications of this metal.

Some of these are reviewed by J. C. Chaston ("Fine Silver as an Engineering Material," *Metal Treatment*, Vol. 5, Winter 1939, pp. 147-150). The properties of

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American metallurgical engineers are somewhat familiar with the work of the Silver Producers' Research Project, some of the developments of which are included in a review of silver's industrial applications by R. H. LEACH of Handy & Harmon ("Silver As a Raw Material," *Chemical Inds.*, Vol. 45, July 1939, pp. 13-19; Sept. 1939, pp. 265-269). Duplex plate (thin sheets of silver welded to base metal) is finding increased application for corrosion resistant equipment, silver on steel, nickel or copper being available. Steel sheets electroplated with silver coatings 0.001 in. thick can be satisfactorily deep drawn. Fine silver can be obtained in the form of sheet, wire and tubing, and readily fabricated into all kinds of apparatus. The disadvantage of high initial cost may be offset by the reclamation value, which often runs as high as 75%.

In the foodstuff and beverage industries, silver-lined containers resist serious contamination and any small amount of organic silver salt formed will not be toxic or affect the color. Miscellaneous applications of silver include its use for mirrors, reflectors, electrical conductors, decoration, dental amalgams, etc. The bactericidal properties of silver are attracting more attention, and the photographic industry is already one of the largest users.

Silver is finding greatly increased application in soldering and brazing alloys. Many of the standard silver brazing alloys contain silver, copper and zinc with the addition in some cases of tin, cadmium or other metals. These alloys offer the advantages of low melting point, resistance to corrosion and great strength. Standard silver solders can be used for joining many non-ferrous metals as well as iron and steel.

Silver is being used more and more as an alloying element. Small amounts of silver added to copper raise the softening temperature. The addition of 3% Ag to tin improves its physical properties. Small amounts of silver in other metals and alloys offer possibilities for investigation, and some work has already been done along these lines. Silver-rich bearing metals are being investigated, and offer considerable promise. [Silver-bearing stainless steel, claimed to possess improved pit-corrosion resistance and machinability, was announced after the publication of this article.] X(3b)

Platinum-Clad Metal-Forms

"PLATINUM-CLAD METALS FOR SHEET, SCREEN, TUBING AND WIRE." FRED E. CARTER (Baker & Co.) *Steel*, Vol. 106, Mar. 18, 1940, pp. 54-55, 83. Practical review.

Platinum-group metals are used for chemical processing equipment because they are unattacked by many strong reagents and the vessels have long life. High cost, however, has been an important factor in limiting their application. Tremendous expansion in application is expected through recently-perfected means of cladding relatively inexpensive base metals with platinum and palladium.

A number of basis materials have been tried experimentally, including nickel, copper, Monel and Inconel. Nickel is the metal used most frequently. Cladding with platinum-rhodium and platinum-iridium alloys also has been developed. These are even harder and more corrosion-resistant than platinum alone. An alloy of 70% Pt and 30% Ir has a tensile strength of 200,000 lbs./in.^{2} when hard-rolled. Sheets clad with platinum-iridium or platinum-rhodium alloys have hardnesses from 70 Brinell as annealed up to 360 Brinell when hard-rolled. The tensile strength of clad sheet, of course, depends largely on that of the base metal.

Platinum-clad and palladium-clad sheets in sizes up to 48x96 in. are available. The method of manufacture involves heating a slab of backing metal and platinum sheet, the two being bonded by pressing them together while hot, the composite slab then being rolled by the usual methods. The thickness of platinum on the finished sheet is usually not less than 0.002-in., as it is difficult to prevent porosity in thinner coatings. Clad wire is also available, and is made by slipping a platinum tube over a base metal rod and then reducing the composite by the usual wire drawing methods. Tubing is made by blanking out a disk of composite sheet and then turning this into tubular form using a tubing press and drawbench. Electroplates of platinum-group metals are practical aids for industrial use under certain conditions of corrosion and wear.

Annealing temperatures must be high—1850° F. for commercial platinum, and 2000° F. for platinum with 5-15% Ir, and 2200° F. when iridium is more than 15%. Platinum is easily spun. Seamless tubing can be made readily. Platinum behaves much like soft copper when fabricated in

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presses and on the lathe, so that the same general practice is used as with pure copper. Great care must be taken in welding platinum-clad material to avoid diffusion of metals into each other, with consequent lowering of resistance to corrosion at the joint. Palladium and its alloys are very similar to platinum in working characteristics, except that lower annealing temperatures may be used. MS (3b)

Oxide Films

A Composite

Recent work by two unconnected researchers indicates that some of our pet theories about the rapid formation of oxide films on "oxidizable" metals freshly exposed to the atmosphere may be slightly haywire. Both used electron diffraction to study the surfaces of several metals and both obtained interesting results.

The formation of oxides at room temperatures (and also at elevated temperatures) on evaporated films of a number of metals and alloys was investigated by M. Bound & D. A. Richards ("A Study of the Atmosphere Oxidation of Metals and Alloys at Different Temperatures by Electron-Diffraction," *Proc. Phys. Soc. London*, Vol. 51, Mar. 1939, pp. 256-265). At room temperature, no oxide films were detected on gold or [very curiously!—J.C.C.] on tin, antimony, lead, zinc or aluminum. Only copper, iron and cadmium formed oxides at room temperature that could be detected by electron diffraction. Silver gave extra rings, which were ascribed to sulphide.

Similarly, electron diffraction studies of sandpapered magnesium samples by S. Yamaguchi ("A Study of Oxide Films on Light Metals by Electron Diffraction: Magnesium, Aluminum and Beryllium," *Sci. Papers Inst. Phys. Chem. Research, Tokyo*, Vol. 36, Dec. 1939, pp. 463-470; in English) showed only the presence, on the surface, of pure magnesium—even after 24-hr. exposure to the atmosphere. Even after heating at 210° F. no oxide film was detected, but heating above 400° F. produced some surface oxide. Likewise, no oxide could be detected on "beryllium" (a 70 Al, 30 Be alloy was actually used) exposed to the atmosphere at room temperature.

On the other hand, the Japanese investigator did find an oxide film on aluminum exposed to the atmosphere at ordinary temperature. The film was gamma-alumina, and the electron diffraction pictures were obtained by the reflection method, despite assertions by others that only the transmission method is suitable for aluminum. X (3b)

Improved Spark Plug Electrodes

"Polonium Alloy for Spark Plug Electrodes." J. H. Dillon (Firestone Tire & Rubber Co.) *J. Applied Physics*, Vol. 11, Apr. 1940, pp. 291-299. Experimental.

By using radioactive material to create ions in the spark gap the required breakdown voltage is decreased, and thus the efficiency of a spark plug may be increased. The suitability of polonium for this purpose is studied. (The use of radium for the same purpose has been covered by patents but its use is still considered too expensive and dangerous.)

Polonium-plated electrodes were first studied but trouble from carbon coating and electrode wear led to their discard in favor of electrodes in which the polonium is alloyed with the electrode metal. With electrodes containing about 200 micrograms of polonium per gram of alloy (0.0002% Po), about 40,000 ions are produced per second in the spark gap. The polonium is stable even at temperatures around 1300° F. and only 10% of it is lost in alloying.

Tests of spark plugs with polonium alloy tips were made by 6 different methods and the results in general indicate a very decided reduction in required breakdown voltage even up to 4 atm. pressure. Such plugs are definitely superior in starting characteristics to identical plugs containing no polonium. HFK (3b)

Sheet Zinc vs. Poison Gases

Zinc Is Giving Valuable Service in A.R.P. Work. R. Lewis Stubbs. *Sheet Metal Ind.*, Vol. 14, Mar. 1940, pp. 293-295. Descriptive.

Sheet zinc has been specified by local British authorities for many purposes, including lining decontamination buildings and mortuary chambers. In decontamination units, it is essential that the materials used should not absorb or readily react with any of the poisonous gases.

Easily hydrolyzed gases (phosgene, etc.) attack all common metals in the presence of water, but are relatively easily dispersed. Lewisite also attacks metals, but slowly, since it decomposes slowly with water. Of the decontamination chemicals, bleaching paste corrodes all common metals, but normally is not sufficiently long in contact to cause trouble. The effect of disinfectants such as Chloramine T on zinc is negligible. Therefore sheet zinc is probably the most economical with respect to cost and durability.

Depending on the conditions of service, zinc may be used mounted on plywood, or unmounted. In either case, soldering is generally necessary for joining. Either a 50-50 or 60-40 non-antimony bearing tin-lead solder is most suitable. Either a non-

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acid flux (*i.e.* zinc ammonium chloride) should be used, or the part should be carefully cleaned after soldering, as otherwise the zinc is attacked by the residual flux.
JZB (3b)

Heat Softening of Pure Aluminum

A Composite

In Germany a large amount of so-called "purest" aluminum (99.99+% Al) is used for electrical conductors, process industry equipment, etc., and considerable "commercially pure" aluminum (99.5% Al minimum) for a variety of industrial and consumer applications. In many instances the metal is employed, for maximum strength, in the cold-worked state, but it softens in service at surprisingly low temperatures.

The extent to which this softening is affected by the amount of previous cold-working and by the purity of the aluminum have been investigated by German workers. Using aluminum containing only 0.0020% Si, 0.0006 Fe and 0.0006 Cu, or 99.9968% Al by difference, H. Wolf & H. Tuxhorn ("Einfluss der Dauererwärmung auf die mechanisch - technologischen Eigenschaften von Reinstaluminium in Abhängigkeit von der Kaltverformung," *Aluminium*, Vol. 22, Jan. 1940, pp. 14-20) studied the effect of continuous heating at relatively low temperatures, as affected by the amount of cold working. The aluminum was heated at 70°, 120°, 160° and 210° F. in an oilbath, and at 400°, 575°, 750° and 950° F. in air and in a salt bath for 1, 10, 100 and 1,000 hrs. and mechanical properties determined.

Practically speaking, when heated for long periods, purest aluminum loses its strength at temperatures as low as 120° F. —irrespective of the degree of cold deformation. The decrease in strength at 400° F. is so great that the soft-annealed state is reached even in short-time heating. In many practical applications it will, therefore, be correct to base the strength only on the values for the soft-annealed state.

The effect of the purity of the aluminum on the heat-softening of rolled aluminum was investigated by K. Schonherr ("Ueber die Abhängigkeit der Warmhärte dis Gewalzten Aluminiums von seinem Reinheitsgrad," *Aluminium*, Vol. 22, Feb. 1940, pp. 68-69). Three grades, containing 99.59, 99.39 and 99.20% Al were tested for Brinell hardness before, during and after heating at 265° F.

The purest sample, initially 35.5 Brinell, dropped to 23 at 265° F. and 34.3 after cooling; the middle-purity sample, originally 42.9, dropped to 25.2 at 265° F. and 38.6 after cooling; the least pure sample, originally 43.3, dropped to 25.9 at 265° F. and 39.5 after cooling. Differences in purity in the ranges studied seem, therefore, to have little effect on the hardness drop after heating at 265° F.
Ha (3b)

Calcium- and Zirconium-Bearing Aluminum and Magnesium Alloys

Investigations on the Diagrams of Aluminum-Calcium, Magnesium-Calcium and Magnesium-Zirconium ("Untersuchungen in den Systemen Aluminium-Kalzium, Magnesium-Kalzium und Magnesium-Zirkon"). Hans Nowotny, Egil Wormnes & Anton Mohrnheim. *Z. Metallkunde*, Vol. 32, Feb. 1940, pp. 39-42. Original research.

Alloys of aluminum-calcium, magnesium-calcium and magnesium-zirconium were studied by X-rays and Brinell tests. In the aluminum-calcium system the existence of two intermetallic compounds Al_4Ca and Al_2Ca was proved. The solubility of calcium in aluminum is 2.8%, 2.2% and 1.7%, respectively, at 1125°, 750° and 570° F. Solution annealing and aging at 570° F. produces distinct precipitation hardening effects in these alloys. Otherwise, the aluminum-calcium alloys were found to be harder than previously reported by Bozza & Sonnino (*Gaz. Chim. Ind.*, Vol. 10, 1938, p. 449).

Previous tests on the solubility of calcium in magnesium are contradictory. The authors' tests yielded: 1.2% at 940° F. and 0.8% at 570° F. Without thermal treatment or aging, the Brinell hardness of the alpha solid solution increases to 39 from 28 for pure magnesium. The X-ray findings and hardness tests are supported by microscopic examination.

Whereas zirconium dissolves not less than 65% Mg, magnesium holds only 0.8% and 0.3% Zr in solid solution at 1300° and 570° F., respectively. The hardness of magnesium is doubled by alloying with 0.8% Zr. Additional hardness was gained by solution anneal and precipitation hardening.

Magnesium and magnesium-calcium alloys with 1.35-26% Ca were submitted to corrosion tests in seawater, *N*/10 and *N*/100 hydrochloric acid and *N*/100 sodium hydroxide. Single-phase alloys were considerably more corrosion resistant than the pure metal or the heterogeneous alloys. The weight loss in seawater, for instance, dropped from 770 g./cm.^{2} a day for pure magnesium to 127 g./cm.^{2} a day with 1.35% Ca. It increased to 4,500 g./cm.^{2} a day with the 26%-Ca magnesium alloy. In contradistinction to this behavior, the heterogeneous magnesium-zirconium alloys were more resistant in seawater and *N*/1, *N*/10, *N*/100 hydrochloric acid than was pure magnesium. However, there was no great difference in alkalies.
EF (3b)

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4 Testing and Control

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Stress Measurement with X-rays

A Composite

Engineers and designers relentlessly pursue the possibility of taking a simple piece of apparatus out into the shop, road or field, and determining quickly the stress conditions present in structures, machines, etc. Therefore, German progress in the use of X-ray diffraction for stress measurement as reported in two recent articles should be of interest.

The determination of stresses in machinery parts by X-rays has progressed much during the last few years, although the available accuracy is still relatively small as compared with extensometers, according to A. Thum, K. H. Saul & C. Petersen ("Röntgenographische Spannungsmessung ohne Eichstoff," *Z. Metallkunde*, Vol. 31, Dec. 1939, pp. 352-358). The X-ray method, however, has one fundamental advantage in that the conditions of the tested area in the stress-free state need not be known; its suitability for very localized stresses is another.

A new method for accurate back-reflection photographs is described that is particularly suitable for the X-ray determination of elastic stresses. The distance between the camera and the object is found by means of an "artificial line obtained by disperse radiation." The use of gold or silver for securing a reference line is unnecessary. The (022) line of iron may be used when steel is tested. For steels, the accuracy of results is claimed to be ± 700 lbs./in.^{2}

Another method of obviating the use of gold or silver powder for calibration is to use chromium powder, which is more suitable anyway, says F. Gisen ("Verwendbarkeit von Röntgen-Rückstrahlinterferenzen zu Spannungsmessungen bei legierten, vergüteten und gehärteten Stählen," *Tech. Mitt. Krupp, Forsch. Ber.*, Appendix 1939, pp. 35-40), investigating the applicability of X-ray diffraction (reflection) for stress measurement in alloyed, annealed and hardened steels.

The usual method, using X-ray tubes of monochromatic radiation (*e.g.* cobalt radiation of 1.78529 A.U.) permits exact evaluation only with annealed steels, and fails with nitrided or hardened steels. By using chromium monochromatic radiation of 2.28503 A.U., very intensive and much more accurate film blackening was produced with all these steels. X (4)

Torsion Creep Tests

Hot Deformation by Torsion (Étude des Déformations à Chaud par Torsion) J. Galibourg & L. Guillet, Jr. *Rev. Mét.*, Vol. 37, Jan. 1940, pp. 1-15. Research.

Torsion tests are more sensitive than tension tests and require less delicate equipment. Variations of temperature during the test affect the deformation in the former only by their effect on the torsional modulus, whereas changes in expansion must also be considered in the latter.

In the equipment used for the elevated temperature tests, the temperature variations amounted to about ±0.4° F. with a resultant error of about 0.005×10^{-3} radians, which was considered negligible. Except for the austenitic steel, 6 hrs. preheating was adequate; however, 24 hrs. was used as a standard preheating period. A constant test time of 72 hrs. was adopted with the rate of flow between the 25th and 35th hrs. also being noted (this time period was used because the Bureau Veritas standard creep test calls for a creep rate of 5×10^{-6} per hr. between the 25th and 35th hrs.). The curve in all cases indicated a constantly decreasing rate of torsion.

Among the low alloy steels, the superiority of the 0.6% Cr, 0.6% Mo steel is marked. Straight lines were obtained when the rates of flow for a constant temperature and steel were plotted on a logarithmic scale *vs.* the torsional load on semi-log paper. Repeat tests for the same load and temperature on the same specimen had no correlation with the results obtained for the first test; however, if the load for the second test were double that for the first test, the results checked the first tests on different specimens with the same load.

There were appreciable deviations from the straight line rate of flow-load relationship; these were especially marked for the 5% Cr steel, but could not be attributed to micro-structure. Further studies were made of "detorsion" as a function of time after removal of the load. These rates, too, could be represented as straight lines on semi-log plots of rate of detorsion (log) *vs.* time. At constant temperature, the total detorsion obtained in 6 hrs. after removal of the load was a straight line function of the load originally applied to the steel in question.

[The tests described should be rated as short-time tests rather than creep tests. Note the statement by Tapsell (p. MA348, second paragraph), that there is no satisfactory rapid method for evaluating creep.—H.W.G.] JZB (4)

Porosity of Electroplates

"Porosity Tests on Electroplated Coatings." P. W. C. Strausser (Natl. Bur. Standards) *Proc. Am. Electroplaters Soc.*, 1939; pp. 194-200. Original research.

The ferroxyl test, much used to detect the porosity of metal coatings on steel, was found to attack nickel coatings and increase their porosity. To overcome this difficulty, a modified ferroxyl test was developed, which consists in placing a sheet of paper moistened with sodium chloride solution (50 g/l.) on the specimen for 10 min. The paper is then introduced into a solution of potassium ferricyanide (10 g/l.), which produces blue spots on the paper wherever the steel has been attacked by the sodium chloride solution through the pores of the coating.

A comparison of the modified ferroxyl test with the hot water test (which consists in developing rust spots by immersing the sample in hot water, 200° F., for 6 hours or more) showed that the latter test did not reveal as many pores as the former. Porosity tests of nickel coatings on brass were unsatisfactory, as they revealed porosities only in coatings about 0.00005 in. thick, but not in coatings about 0.0002 in. thick, which were known to be somewhat porous from the results of atmospheric exposure tests on similar specimens.

Salt spray tests were run on nickel coatings plated on steel, copper, brass, and zinc-base die castings, and the results were compared with the data obtained from atmospheric exposure of the same type of specimens. In general the salt spray test paralleled the atmospheric exposure tests, but it was not a sensitive means of detecting small differences in corrosion resistance, and, in a few cases, even gave inconsistent results. AB (4)

Corrosion Testing of Aluminum

The Standardization of Corrosion Tests for Aluminum ("Die Normung der Korrosionsprüfmethoden bei Aluminium") A. von Zeerleder. *Schw. Archiv angew. Wiss. Tech.*, Vol. 6, Feb. 1940, pp. 33-40. Up-to-date review.

Two corrosion tests are standard in all European countries. The loss of weight of a metal specimen immersed in a solution of 1% sodium chloride and 3% hydrogen peroxide at room temperature during 24 hrs. is employed in the "oxidizing salt test" of Mylius. The total area of the specimen is 2,000 mm.^{2} and its width, if possible, 10 mm. The corrosion products are removed with concentrated nitric acid before the second weighing. The other standard test is the saltspray test, in which a 3%

sodium chloride solution is sprayed against the metal in a tightly sealed chamber; after defined time intervals the losses in ultimate strength and elongation are measured.

A German test not generally used in France and England is the stirring test in an oxidizing common salt solution. The specimens are exposed for a defined length of time to a solution of 3% sodium chloride and 0.1% hydrogen peroxide, kept agitated by a stirrer, and the reductions of ultimate strength and elongation noted. In France the alternating immersion test is in use, where the specimens are submerged in the corroding medium for a defined length of time, and then exposed to air for an equal or different period. The specimens are judged according to appearance, loss of weight, or change of mechanical properties.

Specific tests not in general use are the "thermal" hydrochloric acid test, in which 2,000 mm.^{2} of specimen are exposed to 20 cc. of 10% hydrochloric acid solution at 20° C. and the rise of temperature per min. is measured until a maximum is reached; the gas-evolution test, in which 1,000 mm.^{2} of specimen are exposed to a strong acid or base at 20° C. and the time for 50 cc. of hydrogen to be developed is measured; the grain boundary corrosion test (1,000 mm.^{2} of duralumin shall not develop more than 2 cc. hydrogen in 2 hrs. when exposed to a solution of 3% sodium chloride and hydrochloric acid); and the stress-corrosion test, in which alloys of the aluminum-copper-magnesium type and newer alloys containing $MgZn_2$ as an essential constituent are exposed to a corroding medium while being bent under defined stress. JMN (4)

Electrolytic Etching of Platinum Metals

Etching of the Platinum Metals and Their Alloys with A.C. Electrolysis ("Die Ätzung der Platinmetalle und ihrer Legierungen durch Wechselstromelektrolyse") E. Raub & G. Buss. *Z. Elektrochem.*, Vol. 46, Mar. 1940, pp. 105-202. Descriptive.

It was found possible to dissolve the highly-resistant platinum metals by a.c. electrolysis and to develop well-defined structural pictures. Hydrochloric acid, sulphuric acid and potassium cyanide solutions are electrolytes. A voltage of 2 to 5 v. is required; the current density should be carefully selected to avoid development of major amounts of gas. Bubbles formed on the electrodes should be removed by agitation. The electrolysis is carried out at room temperature. The opposite electrode may consist of carbon or another specimen to be etched.

For platinum, the electrolysis in hydrochloric acid furnished grain etching, and in potassium cyanide grain boundary etching. With concentrated hydrochloric acid, good structures are developed after 5 min. with 0.5 amp./cm.^{2} If, instead a 20% solution is used which is saturated with sodium chloride, very brilliant structures appear after 70-15 min. with current densities of 0.02 to 0.2 amp./cm.^{2}

For iridium, diluted hydrochloric acid produces the desired structure (grain boundary etching) with 0.02 to 0.1 amp./cm.^{2} after 180-30 min. Sulphuric acid is more rapid in its attack on iridium; different thicknesses of deposits permit differentiation of the grains. For etching rhodium, hydrochloric acid and potassium cyanide are best. First the grain boundaries are developed, and later the grains become more prominent and show clear etching figures. Twin formation was noted, which was not observed in any other metal of this group. The a.c. electrolysis is not suited for etching palladium because of hydrogen absorption by the metal.

Platinum-ruthenium and platinum-osmium can be etched in sulphuric acid by a.c. electrolysis, producing typical grain area etching. Platinum-iridium and platinum-rhodium cannot be so treated. With these, hydrochloric acid is used for grain etching and potassium cyanide for grain boundary etching. Platinum-iridium alloys solidify with crystal layer formation, which may be seen in the dendritic structure. The dendrites are rich in iridium, the remaining melt solidifying in between the branches. After severe cold-working this can no longer be distinguished. In the alloy with 5% Ir the grains grow rapidly with the annealing temperature. This is true for the 20% Ir alloy to a lesser degree, while in the 40% Ir alloy the grain growth is still less pronounced.

Platinum-rhodium (20%) sheet shows a rolled structure which would appear to correspond to a lower degree of working. Annealing at 2500° F. produces recrystallization and considerable grain growth. With slow solidification after melting, a relatively coarse grain appears free from distinct layer formation. The platinum-ruthenium alloy recrystallized at 3,000° F. shows coarse grain. Annealing was carried out in an alumina crucible under hydrogen; owing to the reducing reaction some aluminum entered the alloy. Platinum-osmium rolled sheet recrystallizes at 2900° F. with grain growth; portions of the grain boundaries are ruptured by vaporization of osmium textroxide.

Etching of osmium-iridium alloy in hydrochloric acid was unsuccessful. Dissolution occurs, however, during a.c. electrolysis in sulphuric acid; a loose deposit is formed which may be removed by a short secondary electrolysis in potassium cyanide. Thus treated, the osmium-iridium alloy shows 2 phases, one of which appears light and occurs at the grain boundaries. The predominant phase has a "martensitic" structure. It is concluded, therefore, that a transformation or segregation takes place whose exact nature is to be investigated later. RPS (4)

Industrial Radiography

"Industrial Radiography." Royal G. Tobey (Eastman Kodak Co.) *Iron Age*, Vol. 145, Feb. 29, 1940, pp. 27-30; Mar. 7, 1940, pp. 64-68. Practical, descriptive review.

The thickness of material that can be penetrated is directly related to the kv. capacity of the X-ray equipment. Equipment has increased progressively from 100 to 400 kv. capacities. Practical penetration of steel has increased from 1 to 5 in. Most industrial machines are now shock and ray-proof.

Continuous inspection is done by means of fluoroscopic units. The X-ray tube is usually mounted below or behind a moving belt which carries the articles to be inspected between the X-ray tube and a chemically treated screen. The chemicals on the screen emit a greenish-yellow light whose intensity depends on the X-ray energy reaching screen. The operator can use a mechanism that rejects questionable items for further inspection.

Various techniques are used to produce radiographs of widely different materials encountered. The proportion of secondary radiation from aluminum and steel, when radiographed by direct X-ray technique, increases almost linearly with thickness, and nearly half of this radiation can be removed by the use of lead-foil screens in contact with the film. When the object radiographed does not cover the whole film, those areas of film outside the shadow may receive very intense exposure, giving rise to halation from X-rays and light diffusing into image. To protect the outer film areas it is customary to cover them with lead, plastic barium clay or an X-ray absorbing solution. The use of fine metal shot, which has the advantage of flowing freely so that it will readily be filled around irregular objects, is suggested.

Little has been said in this country about flexible industrial calcium tungstate intensifying screens, which have the advantage of being flexible on a short radius. Investigations on the use of these screens with gamma-rays indicate that they are applicable only when good contrast and sensitivity in the detection of flaws is not required. Photographic materials when exposed to light such as that of a fluorescent screen do not produce density according to the product of light times the duration of exposure. A 1/32 in. filter placed on the face of the cassette improves the quality of radiographs made with fluorescent screens. Lead screens can often be used when calcium tungstate screens would be barred because of the unsharpness they produce in the image; this is generally the case in gamma-ray work.

Direct exposure film has an increased sensitivity to direct X-rays, and is intended for use when fluorescent intensifying screens are unnecessary or unsatisfactory. When exposed to 200 kv. radiation, it has a direct X-ray speed more than twice that of the regular screen type film. VSP (4)

Bend-Tensile Testing

The Bending-Tensile Test, A New Testing Method for Metallic Materials ("Der Biegezugversuch, ein neues Prüfverfahren für metallische Werkstoffe") E. Mohr. *Z. Ver. deut. Ing.*, Vol. 84, Jan. 20, 1940, pp. 49-52. Descriptive.

The bend-tensile test, applied for testing sheet, strip and wire, consists in bending specimens to and fro about a small angle over rolls, with simultaneous application of a static load, until fracture occurs. The specimens all have the same dimensions and the load is changed from specimen to specimen from a small amount up to a load close to the ultimate strength.

The diagrams are plotted so that the number of the bend cycles causing fracture appears as a function of the static tension. These curves show a marked point of inflection, sometimes almost a discontinuity, which becomes particularly clear if the abscissa is plotted logarithmically. The tension corresponding to this inflection point is the bend-tensile strength and seems to be a characteristic value closely connected with the fatigue (bending) strength.

The most suitable bending angle is 20°, while the roll diameter and the specimens can have various but carefully selected dimensions. The selection of best conditions for a given case is discussed and examples of tests for several materials are described. As the stresses occurring in this test are similar to those in practical deformation, the test is of particular value in providing quick determination of the suitability of a sheet to resist a combination of stresses, *e.g.* bending, stretching, upsetting, etc. in actual service. Ha (4)

The TOOLS of the CHEMIST

Their Ancestry and American Evolution

by

ERNEST CHILD

Foreword by C. A. Browne,
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This handsome and lavishly illustrated volume is the first to be devoted to a subject which has long been neglected—the history of the manufacture of laboratory apparatus and the part it has played in the development of American chemistry. In an entertaining and instructive way, the author describes the events and personalities that were responsible for the creation and growth of chemical laboratories in this country, with appropriate emphasis on the European background from which they sprang. He infuses his work with the spirit of Holmyard's remark, "Every piece of apparatus hides a romance." The history of many famous manufacturers of instruments and apparatus and dealers in chemical supplies is given in much detail; and many facts are presented that were heretofore unknown, thanks to the persistence with which the author has collected his material. He traces the history of such laboratory necessities as balances, glassware, filter paper, porcelain, heating apparatus, metal ware, Alundum, rubber ware, platinum ware and scientific optical instruments. The contributions of various cities and sections of the country to this field are also discussed.

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Ernest Child has devoted many years of painstaking research to the production of this volume. Long associated with manufacturers and dealers in chemical equipment in both Europe and America, he has had the opportunity to visit leading educational and industrial laboratories and to obtain through his many contacts the outline of this valuable history. His own perseverance in tracking down details has enabled him to fill in this outline, and make it a connected whole. The result of his efforts will be applauded by the entire chemical profession.

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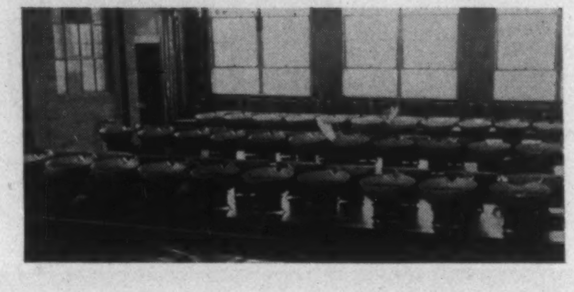

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books

Precious Metal Recovery

Refining Precious Metal Wastes. *By C. M. Hoke. Published by Metallurgical Publishing Co., New York, 1940. Cloth, 6x9 in., 362 pages. Price $5.00.*

As stated by the author this book is intended to teach the jeweler or dental technician how to handle all kinds of precious metal wastes. It is written for the man without a knowledge of chemistry. Consequently, part of the book necessarily had to be elementary in character, yet the technically trained man who wishes to get information regarding silver, gold and the platinum group metals will find this book a veritable mint of information. The fundamental information, helpful data and practical procedures are based not only on the existing literature but also on the author's own personal experience as a consultant to the jewelry trade.

In addition to the recovery and refining of precious metals from various types and compositions of jeweler's and dental wastes, two chapters are devoted to the processes used by the smelting and refining industries and description of various operating plants are given. A valuable appendix describes in detail the methods of melting the precious metals and includes an excellent bibliography.

The book will be enthusiastically received by the industry for which it was written and will be found valuable by all interested in silver, gold and particularly the platinum group metals.—S. Skowronski.

High-Chromium Iron Alloys

The Alloys of Iron and Chromium. Volume II—High-Chromium Alloys. *By A. B. Kinzel & Russell Franks. Published by McGraw-Hill Book Co., New York, 1940. Cloth, 6¼ x 9¼ in., 559 pages. Price $6.00.*

This, the 11th volume in the Alloys of Iron monographs, deals with the oxidation- and corrosion-resistant alloys with 10 per cent or more chromium, as well as with the high-carbon, high-chromium wear resistant steels and cast irons. Nearly half is devoted to austenitic chromium-nickel, chromium-manganese, and chromium-manganese-nickel steels.

Some of the topics are none too simple, nor too easily understood, but this volume goes far toward systematizing them and making them understandable. While a good many questions could be raised that are not answered in the book and while there is pertinent unpublished information on some of the topics that could not be included, the book is quite complete with respect to published data, and the information is presented in clearer fashion than in the earlier books devoted to the high-chromium steels. Covering the subjects as fully as they have been covered without condensing so far as to be unclear, or expanding so much as to be verbose, is quite a feat.

The usual form of the monographs is followed, text, figures and tables being used to present the facts, with running comment on discrepancies, and with the authors' summary at the end of each chapter. As one has come to expect of each of these monographs, it will be indispensable in any metallurgical engineering bookshelf, for it will save a vast deal of reference to earlier literature.—H. W. Gillett.

Metal Cutting

Manual on Cutting of Metals. *Published by Am. Soc. Mechanical Engineers, New York, 1939. Flexible binding, 5¾x8½ in., 319 pages. Price $5.00 to non-members.*

Condensed discussion is given of the effect of tool shape and chip proportions, of rigidity of the tool, of cutting fluids, etc., on the machining of metals in lathe turning. The variables affecting the operation are reduced to a formula and the constants to use in the formula for a given case are given in extensive tables. For each of the S.A.E. steels, in five conditions of heat treatment, are shown the mechanical properties, the formula constants, multipliers for speed and horsepower for use with other tables, and the relative machinability. Hot-rolled 1020 is taken as the base line. Similar data are given for a variety of cast irons and non-ferrous alloys.

The next set of tables gives the speed and the horsepower required, at different feeds and depths of cut for a tool life of 60 min., using tools of carbon steel, high speed steel, Stellite J metal, and cemented carbide.

Formulas are given for determination of economic tool life, according to the rates of pay of the workers. Finally, methods of making lathe tool and machinability tests are discussed.

The data on relative machinability of various steels and non-ferrous alloys are of interest to the metallurgical engineer, as are the comparisons of the cutting power of the various tool materials. The text is sketchy in respect to the heat treatment of tools. In the text, molybdenum high speed steel is left in a rather hazy position, *i.e.* maybe it is and maybe it isn't equivalent to 18-4-1. However, in the tables, page 100 and page 255, the factors for the formulas are identical, so on that basis it appears that the committee doesn't find it necessary to take cognizance of any difference in performance of properly hardened and tempered tools of either composition.

The user of the manual is not warned, unless in fine print somewhere that the reviewer hasn't been able to find, that a given S.A.E. steel, heat-treated in a given way, may not have the properties, structure or machinability recorded in the tables, if it has a section other than that (presumably 1 in. dia.) for which the tables are prepared. No effort is made to correlate machinability with structure although the preface says that in experimental work carried out to fill gaps, photomicrographs of the tools and the materials cut were made at Stevens Tech. This is doubly surprising because the A.S.M.E. committee includes two well known metallurgists, but their voices must not have been heard in the committee councils.

The work of French and Digges is relied upon for much of the basic data upon which the tables are constructed. Those workers were not blind to the relation between structure and machinability of the work and between structure and performance of the tool, so the compilers of the tables certainly had the matter of structure before them. Some attention to the work of Ernst, whose publications are not even listed in the bibliography, would have helped the manual. Metallurgically, the manual has a blind spot, for which we can see no excuse.—H. W. Gillett.

Other New Books

Tools of the Chemist—Their Ancestry and Evolution. *By E. Child. Published by Reinhold Publishing Corp., New York, 1940. Cloth, 5¾ x 8½ in., 220 pages. Price $3.50.* Historical rather than technical. The development of such tools as balances, stills, platinum ware, laboratory furnaces, etc., is traced in interesting fashion, with many quaint illustrations.

highlights

Do you want to know what metallurgical engineers are doing, the world over? Look in the Metallurgical Engineering Digest. Here are some of the points covered by authors whose articles are digested in this issue.

Pure Manganese

The manufacture of pure metallic manganese by an electrolytic method attracted wide attention at the National Metal Exposition in October. Information, in the form of a "composite digest," as to its manufacture and uses, gleaned from several sources is presented (page MA 47 L 5) so that "he who runs may read" and obtain a good general knowledge of this new development.—E. F. C.

Hydrogen Again

Accentuation of the tendency to form long, rather than equiaxed, crystals in the freezing of a steel ingot is ascribed by Hohage and Schäfer (page MA 18 R 9) to hydrogen. One more sin in a long list committed, or alleged to be committed against metals by the light gas, such as that of producing blisters and porosity in Al, with which Winterhager (page MA 20 R 2) deals.—H. W. G.

Zinc

Digests of three articles on zinc (pages MA 40 L 1, MA 40 R 10 and MA 48 L 7) offer a wealth of information on the progress in alloys of zinc since 1900, on the physical properties of some zinc alloys at elevated temperatures, and on the metal itself.—E. F. C.

Electric Heating for Straightening

Opitz (page MA 17 L 5) advocates the use of equipment for applying a shot of heavy current to the work in the straightening machine, apparently with the main object of avoiding damage to the machine through breakage of the piece being straightened. It might also be good medicine for a piece that didn't break but just cracked a bit and nobody found it out till it broke in service!—H. W. G.

Corrosion of Magnesium Alloys

An informative German article (page MA 41 L 2) on the corrosion protection of magnesium and its alloys contains the interesting statement that beryllium, in amounts as low as 0.005 to 0.5 per cent, extraordinarily increases the corrosion resistance when alloyed with magnesium. Other valuable data are given.—E. F. C.

Die Casting Practice

Three articles—one on general die casting practice, a second on the manufacture of magnesium alloy die castings, and a third on the durability of equipment for die casting zinc alloys—are digested together in a "composite" beginning on page MA 20.—F. P. P.

Isothermal Transformations

To the data from Davenport (page 24 L 6) the reader may add that provided in this issue by Parke and Herzig on pages 6-13.—H. W. G.

Welding Galvanized Sheets

The recommendations of Landis and of Eckberg as to filler metal to be used in the carbon-arc welding of galvanized sheets are compared in a composite digest (page MA 28). One likes Everdur; the other favors tin-coated copper-silicon alloy, as the tin is said to replace the volatilizing zinc coating.—F. P. P.

Atmospheres in the Melting of Copper

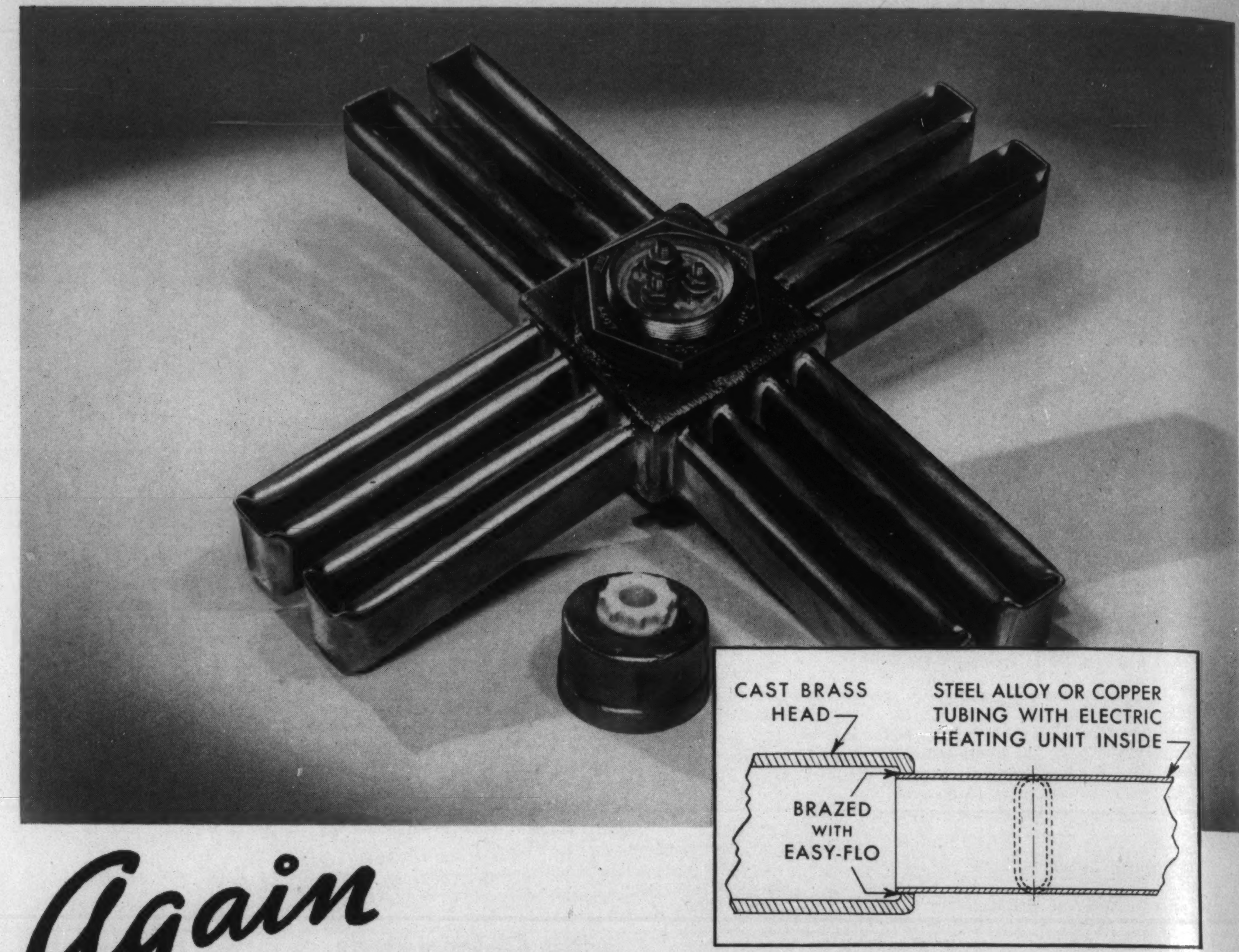
Since CO_2, at the melting point of Cu, is oxidizing to Cu, no wonder Baranov (page MA 20 R 5) had to use Li or Be as a deoxidizer. Of course if he had used CO instead of CO_2 he would have gotten oxygen-free Cu much more easily, and with only C as a deoxidizer, hence no solid products of deoxidation, but that wouldn't sound novel. (See *Metals and Alloys,* Vol. 8, Feb. 1937, p. 33.)—H. W. G.

Electrocleaning

The process of electrolytic cleaning with simultaneous deposition of a metal film (copper) is comprehensively discussed by Sacchi (page MA 23). Mechanism of the reactions and operating formulas and conditions are given.—F. P. P.

Electrolytic Polishing

To the dope given by Jacquet and Elmore (page MA 23 L 6) the reader may well add that for stainless given by Kiefer in *Iron Age,* Vol. 144, Dec. 21, 1939, p. 30.—H. W. G.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editorial

Bibliofilm

Most professional people are aware that there is such a thing as "Bibliofilm," but its utilization is still relatively rare.

The process might be called photostating in miniature, instead of copying photographically full size. The material to be copied is photographed much reduced, on roll film, and viewed in a simple enlarging device. Of special importance to librarians is the fact that whole books may be copied and the film stored in very little space, and that out-of-print books may be easily duplicated.

However, typed material may be copied as well as that which is printed, so this opens up a way of distributing material which will not bear the cost of printing. For example, if a research worker assembles a comprehensive bibliography on some subject, for his own use, availability of such material may save others a great deal of work, yet few journals can find space to print such a bibliography.

A patent attorney who is also a metallurgist wrote us recently that he was making a search on a metallurgical subject of rather wide interest and inquired whether such a search would find a publisher. We know of no journal whose available space and funds would permit such publication. Patent lawyers as a rule would not be in favor of such publication since it would obviate the necessity for duplicate searches by other lawyers, or at least greatly shorten their task. But many metallurgical organizations have patent searches made by technical men, not lawyers, from their own group, and such searchers may well turn out better ones than those made by a non-metallurgical lawyer, since the pertinent literature other than patents alone, is more intelligently surveyed and the technical man usually grasps the nub of the matter better than the lawyer.

Some such searches are not publishable, since it would be a tip as to the interest of the firm in some topic when such a tip could not be given, yet publication of the vast majority of searches would be entirely innocuous.

When conditions exist under which the laboriously made bibliographies and searches might just as well as not be made generally available, Bibliofilm would be a fine answer to the problem of how to disseminate the information. All that is needed is that the existence of such films be publicly recorded so that anyone interested may get them on payment of the cost, which is a mere nothing to the cost of duplicating the work of assembly of the material.

The time will doubtless come when utilization of the Bibliofilm method is so widespread that each issue of a technical journal will carry, beside its articles and abstracts, a list of the new subjects available in Bibliofilm since the previous issue.

We shall be delighted to carry such notices in METALS AND ALLOYS for films dealing with metallurgical and closely allied topics. Ultimately it should be a matter for consideration by all technical laboratories whether or not a given bibliography or search should be published via Bibliofilm before the project is considered closed. If even a relatively small number will adopt such a policy, each one will in the long run, get far more than he gives.—H.W.G.

German Theses

According to *Nature* for Nov. 18, a Nazi rule has been promulgated that all doctors' theses in German universities have to be submitted to and passed by the censors, before they go to the faculty for examination on a scientific basis. We wonder if that means that footnote references to prior work of expelled or liquidated Jewish scientists will be deleted. And the picture of a Nazi politician trying to read a scientific thesis, calls for a chuckle. Wouldn't that be cruel and inhuman punishment even for a Nazi? —H.W.G.

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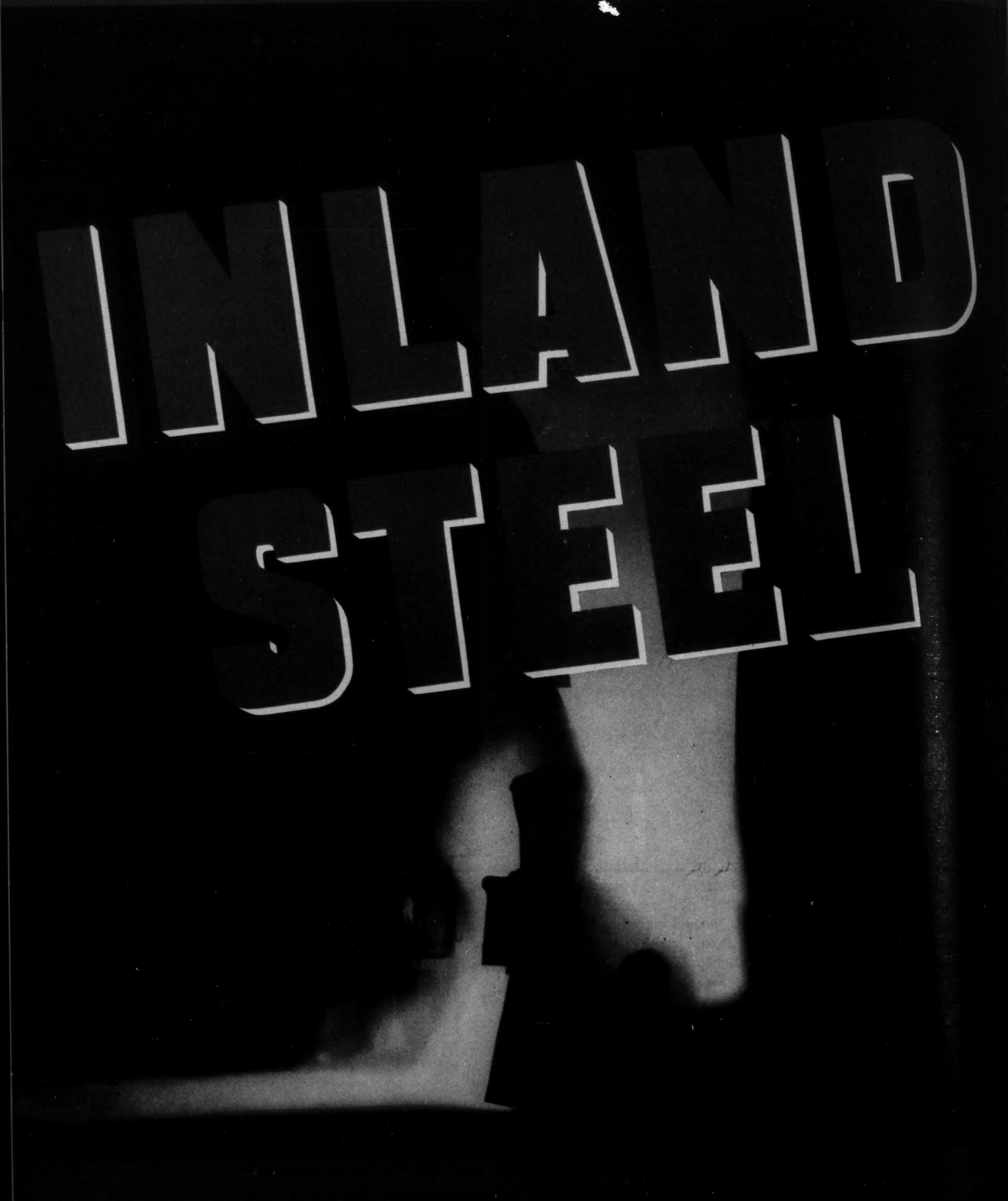

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The 152nd meeting of the A.I.M.E. is scheduled at the Engineering Societies Building, New York, Feb. 12 to 15. The tentative technical programs of the two metals divisions of the Institute are as follows:

Iron and Steel Division

TUESDAY MORNING, FEB. 12—*Chemistry of Steelmaking*

"Slag-metal Relationships in the Basic Open-hearth Furnace," by Karl L. Fetters, Res. Asst., and John Chipman, Prof., Dept. of Met., Mass. Inst. of Tech.

"Formation of Inclusions in Steel Castings," by Walter Crafts, John J. Egan and W. D. Forgeng, Res. Mets., Union Carbide and Carbon Res. Labs., Inc.

"The Carbon and Other Reaction Mechanisms in the Open-hearth Process," by B. M. Larsen, Phys. Chemist, Res., Lab., U. S. Steel Corp.

TUESDAY NOON, FEB. 13—*Executive Committee, Iron and Steel Division, and Committee on Blast Furnaces and Raw Materials, Luncheon Meetings*

TUESDAY AFTERNOON, FEB. 13—*Chemistry of Steelmaking (Second Session)*

"Equilibria in Liquid Iron with Carbon and Silicon," by Lawrence S. Darken, Res. Lab., U. S. Steel Corp.

"Solubility of Nitrogen in Liquid Fe-Cr and Fe-V Alloys," by R. M. Brick, Instr. of Met., Yale Univ., and J. A. Creevy, The Stanley Works.

"Heat Capacity of Iron Carbide from 68° to 298° K. and the Thermodynamic Properties of Iron Carbide," by Harry Seltz, Prof. of Phys. Chem., Carnegie Inst. of Tech., Hugh J. McDonald, Armour Inst. of Tech., and Cyril Wells, Metals Res. Lab., Carnegie Inst. of Tech.

"Thermochemistry of the Pig-iron Blast Furnace," by Julian M. Avery, Arthur D. Little, Inc.

WEDNESDAY MORNING, FEB. 14 — *Recrystallization (Third Session)*

(Joint Session with Institute of Metals Division)

WEDNESDAY MORNING, FEB. 14—*Control of Surface Qualities of Steel*

"A Survey of Factors Affecting the Surface Quality of Semi-finished Steel," by H. B. Emerick, Supervisor, Investigation Div., Jones & Laughlin Steel Corp.

"Pouring Practice Variables and Their Individual Effect on Ingot Surface," by W. A. Saylor, Asst. Chief Met., Duquesne Works, Carnegie-Illinois Steel Corp.

"Influence of the Chemical Composition of Steel on the Freezing, Heating, Scaling, and Rolling Characteristics," by Gilbert Soler, Res. Mgr., Steel and Tube Div., Timken Roller Bearing Co.

"Relation of Ingot Surface as Reflected by Mold-wall Surface to Billet or Bloom Surface," by T. J. Woods, Met. Dept., Republic Steel Corp.

WEDNESDAY NOON, FEB. 14—*Luncheon Meeting, Iron and Steel Division*

WEDNESDAY AFTERNOON, FEB. 14—*Carbon and Low-alloy Steels*

"Precipitation Hardening of a Complex Copper Steel," by J. W. Halley, Met., Inland Steel Co.

"Tensile Strength and Composition of Hot Rolled Plain Carbon Steels," by C. F. Quest, Dept. of Met., Univ. of Minn., and T. S. Washburn, Asst. Chief Met., Inland Steel Co.

"Effect of Composition and Steel Making Practice on Graphitization Below the A_1 of Eighteen One Per Cent Plain Carbon Steels," by Charles R. Austin, Prof. of Met., and Maurice C. Fetzer, Instr. in Met., The Pennsylvania State College.

WEDNESDAY AFTERNOON (4 o'clock) FEB. 14—*Institute of Metals Lecture*

(See Institute of Metals Division program)

THURSDAY MORNING, FEB. 15—*Diffusion and Decomposition in Austenite*

"Rate of Diffusion of Carbon in Austenite in Plain Carbon, in Nickel and in Manganese Steels," by Cyril Wells, Metals Res. Lab., and Robert F. Mehl., Dir., Metals Res. Lab., Carnegie Inst. of Tech.

"Crystallography of Austenite Decomposition," by Alden B. Greninger, Asst. Prof. of Met., Harvard Univ., and Alexander R. Troiano, Asst. Prof. of Met., Univ. of Notre Dame.

THURSDAY NOON, FEB. 15—*Executive Committee, Open-Hearth Conference, Committee on Physical Chemistry of Steelmaking, Bessemer Steel Committee, Luncheon Meetings*

THURSDAY AFTERNOON, FEB. 15—*Austenitic Stainless Steels*

"Effects of Low-temperature Heat-treatment on Elastic Properties of Cold-rolled Austenitic Stainless Steels," by Russell Franks, Res. Met., and W. O. Binder, Union Carbide and Carbon Res. Labs., Inc.

"Effects of Temperature of Pretreatment on Creep Characteristics of 18-8 Stainless Steel at 600° to 800° C.," by Charles R. Austin, Prof. of Met., and Carl H. Samans, Asst. Prof. of Met., The Pennsylvania State College.

THURSDAY AFTERNOON (4 o'clock) FEB. 15—*Howe Memorial Lecture*

"Slag Control," by Charles H. Herty, Jr., Res. & Dev. Dept., Bethlehem Steel Co.

Institute of Metals Division

TUESDAY MORNING, FEB. 13—*Recrystallization*

"Recrystallization Texture of Aluminum After Compression, by Charles S. Barrett, Phys., Metals Res. Lab., Carnegie Inst. of Tech.

"Plastic Deformation and Recrystallization of Aluminum Single Crystals," by J. A. Collins, Met., E. I. duPont de Nemours & Co., and C. H. Mathewson, Prof. of Met., Yale Univ.

"Effect of Cold-work upon Hardness and Recrystallizing Behavior of Pure Platinum," by E. M. Wise and R. F. Vines, Res. Lab., The International Nickel Co., Inc.

"Some Factors Influencing the Recrystallization of Cold-worked Metals, as Observed on Nickel," by Erich Fetz, Res. Met., Wilbur B. Driver Co.

TUESDAY AFTERNOON, FEB. 13—*Recrystallization (Second Session)*

"Changes in Damping Capacity During Annealing of Alpha Brass," by John T. Norton, Assoc. Prof. of Physics of Metals, Mass. Inst. of Tech.

"Variation of Internal Friction with Grain Size," by Clarence Zener, Instr., and R. H. Randall, Asst. Prof., Physics, College of the City of New York.

"Recovery and Recrystallization in Long-time Annealing of 70:30 Brass," by S. E. Maddigan, Res. Phys., and A. I. Blank, Res. Asst., Chase Brass & Copper Co., Inc.

"Correlation of the Deformation and Recrystallization Textures of Rolled 70:30 Brass," by R. M. Brick, Instr. in Met., Hammond Lab., Yale Univ.

WEDNESDAY MORNING, FEB. 14 — *Recrystallization (Third Session)*

(Joint Session with Iron and Steel Division)

"Some Observations on the Recrystallization of an Iron-nickel Alloy," by George Sachs, Asst. Prof. of Met. Engrg., and Joseph Spretnak, Grad. Asst., Dept. of Met. Engrg., Case School of Applied Science.

"Crystal Orientation in Silicon-iron Sheet," by J. T. Burwell, Res. Lab., U. S. Steel Corp.

"X-ray and Microscopic Study of Imperfection Recrystallization Textures," by Norman P. Goss, Phys., Cold Metal Process Co.

"Effect of Time, Temperature and Pressure upon the Density of Sintered Metal Powders," by F. C. Kelley, Met., Res. Lab., General Electric Co.

WEDNESDAY AFTERNOON, FEB. 14—*Copper and Silver Alloy Systems*

"The Copper-rich Alloys of the Copper-nickel-phosphorus System," by D. K. Crampton, Dir. of Res., H. L. Burghoff, Res. Met., and J. T. Stacey, Res. Asst., Chase Brass & Copper Co., Inc.

"A Metallographic Study of Internal Oxidation in the Alpha Solid Solutions of Copper," by Frederick N. Rhines, Asst. Prof. of Met., Carnegie Inst. of Tech.

"An X-ray Study of the Silver-lead and Silver-bismuth Systems," by Haim H. Chiswik, Asst. in Met., and Ralph Hultgren, Asst. Prof. of Met., Harvard Univ.

WEDNESDAY AFTERNOON (4 o'clock) FEB. 14—*Institute of Metals Lecture*

"Acceleration of Rate of Corrosion by High Constant Stresses," by E. H. Dix, Jr., Chief Met., Aluminum Res. Labs., Aluminum Co. of America.

THURSDAY MORNING, FEB. 15—*General Physical Metallurgy*

"An Electron Diffraction Study of Anodic Films," by R. A. Harrington, B. F. Goodrich Co., and H R. Nelson, Res. Phys., Battelle Memorial Institute.

"Determination of Orientations by Etch Pits," by Charles S. Barrett, Phys., and L. H. Levenson, Res. Asst., Metals Res. Lab., Carnegie Inst. of Tech.

THURSDAY NOON, FEB. 15—*Executive Committee, Institute of Metals Division, Luncheon Meeting*

THURSDAY AFTERNOON, FEB. 15—*Alloy Systems*

"The Cobalt-nickel-silicon System between 0 and 20 Per Cent Silicon," by Arthur C. Forsyth and R. L. Dowdell, Prof. of Metallography, Univ. of Minn.

"The Process of Precipitation from Solid Solution, I—A Crystallographic Mechanism for the Aluminum-copper Alloys," by Carl H. Samans, Asst. Prof. of Met., The Pennsylvania State College.

THURSDAY AFTERNOON (4 o'clock) FEB. 15—*Howe Memorial Lecture*

(See Iron and Steel Division Program)

THURSDAY EVENING, FEB. 15—*Venetian Room, The Biltmore Hotel, Annual Institute of Metals Division Dinner; Presentation of the I.M.D. Annual Award for 1940*

After-dinner talk, *"Exploring the Magic World of Color,"* by Herbert T. Strong, color consultant, New York Museum of Science and Industry.

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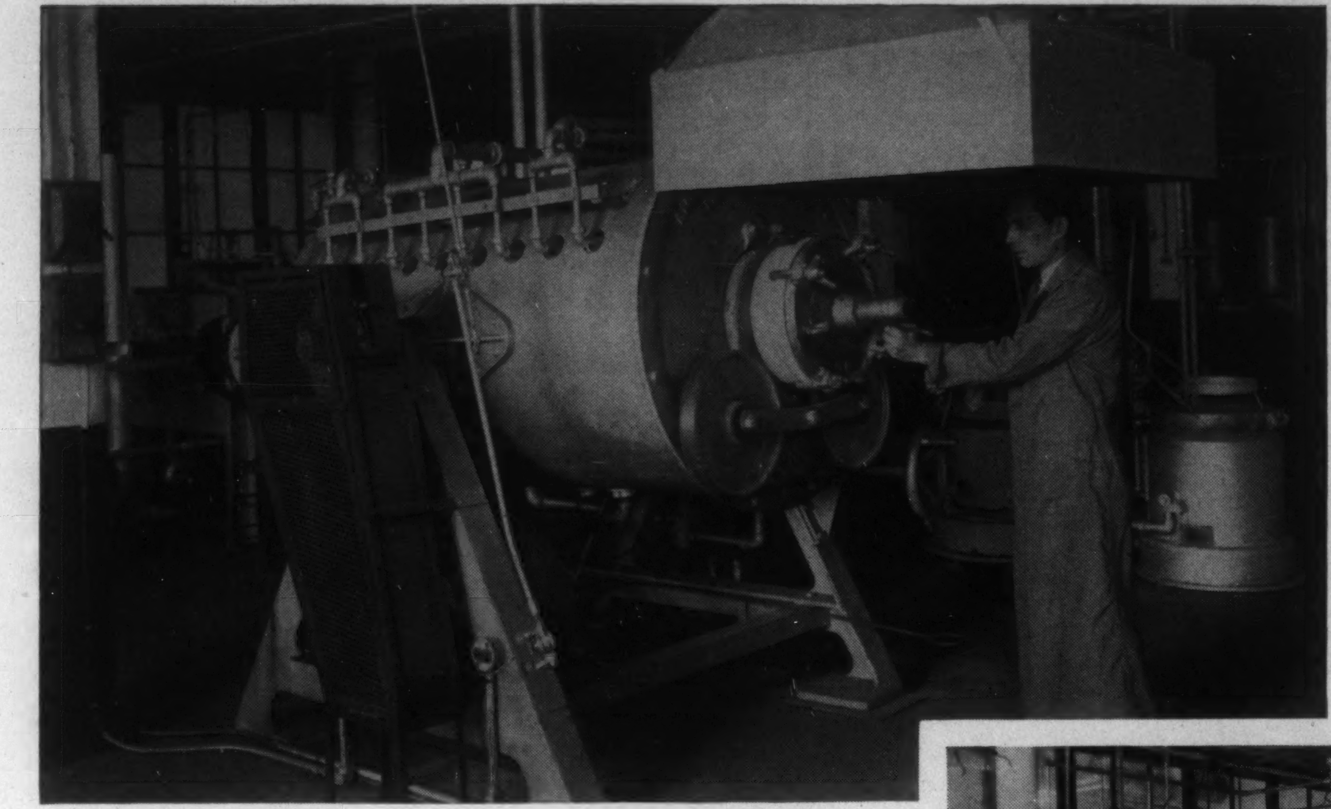
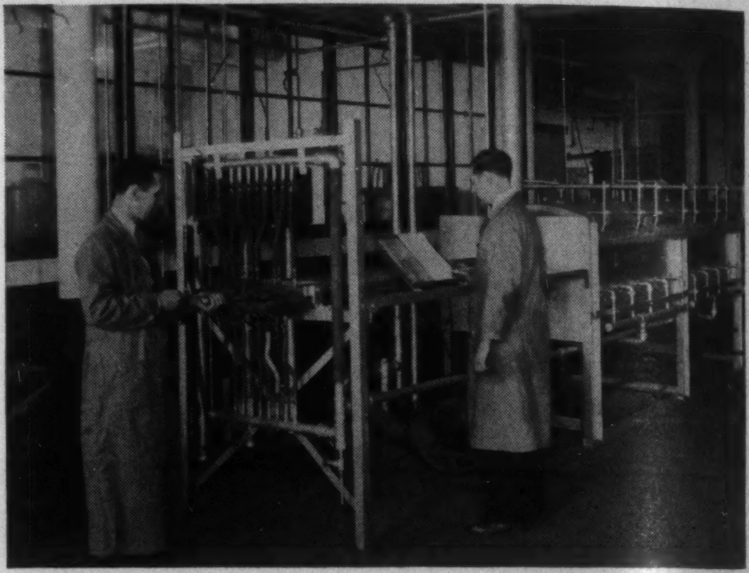


Elaborate heat-treating furnace installation in plant of Sirian Wire and Contact Co., Newark, N.J. Photograph courtesy American Gas Furnace Co. Elizabeth, N. J.



Checking each minute step in the transformation of tungsten and molybdenum from mere white and gray powders into ingots ready for their role in lighting and radio.

Rare metallic elements tamed by heat-treating with GAS

IN producing fine tungsten filaments for incandescent lamps and radio tubes, and molybdenum radio tube grids and grid supports, the Sirian Wire and Contact Co., Newark, N.J., finds Gas a definitely superior fuel.

Not only do the infinite heat-treating processes call for modern Gas equipment, but A. E. McFarland, president, says: "There is no comparison between this type of furnace and the electric furnaces formerly used, either as to economy or flexibility in the reduction of tungsten and molybdenum metals. As a matter of fact, our process has been built around the Gas furnace."

What makes the story more interesting to the heat-treating industry is the fact that tungsten is known to have the highest melting point of any metal in commercial use, while molybdenum's use in radio is due to its own very high melting point and its electrical characteristics; it is used for resistance windings in electric furnaces.

The most exacting requirements of heat treating metals are so perfectly fulfilled by the use of Gas-fired equipment that "it is a compliment both to the fuel itself and to the success of the Gas equipment manufacturers in developing superlatively fine industrial equipment," reports W. D. Relyea, in "Industrial Gas."

Your own heat-treating problems may turn your attention to Gas. Why not investigate?

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highlights

Do you want to know what metallurgical engineers are doing, the world over? Look in the Metallurgical Engineering Digest. Here are some of the points covered by authors whose articles are digested in this issue.

Three Columns

In this issue the digests are presented in 3-column arrangement. This has been caused by the larger number of so-called "island" or half pages which preclude the use of the former 2-column set-up. We hope that the change will be favorably received.—E. F. C.

Tarnish Resistant Silver

According to Raub and Engel (page MA 99) the much talked of Price and Thomas treatment, alleged to make silver non-tarnishing is just another false alarm, "value nil."—H. W. G.

Welding Wire

Joublanc (page MA 82) advocates using metallic antimony in a welding rod coating, to decrease surface tension.—H. W. G.

Electropolishing

As applied to stainless steel, electropolishing is a comparatively new development. It is also important and, while considerable refinements are still necessary, it has a decided future. A composite digest (page MA 88) gives the busy reader an idea of the present status of this new art. —E. F. C.

Pink or Blue?

Miss Gayler (page MA 100) reports a blue, alpha CuAl$_2$ and a pink, beta CuAl$_2$, reminding one of the ribbons used to decorate the clothes of boy and girl babies.—H. W. G.

Flame Hardening. How About Endurance?

On page MA 85 some features of flame hardening are discussed. In all the literature on induction hardening and flame hardening, we recall no work to evaluate the endurance of plain and notched specimens surface hardened by these methods, though carburized and nitrided steels have been so studied.—H. W. G.

Metals vs. Plastics

The competition between metals and plastics for the design engineer's attention is evident in the composite digest on page MA 94. Not mentioned there is the recently announced plastic-fuselage airplane, which, if worth anything, just about silences all our metallurgical huzzahs over the not-so-old metal wing plane. But all this is progress, and if plastics lead to better products, stimulation of research among alloy producers is certain to follow.—F. P. P.

Electric Steel Castings

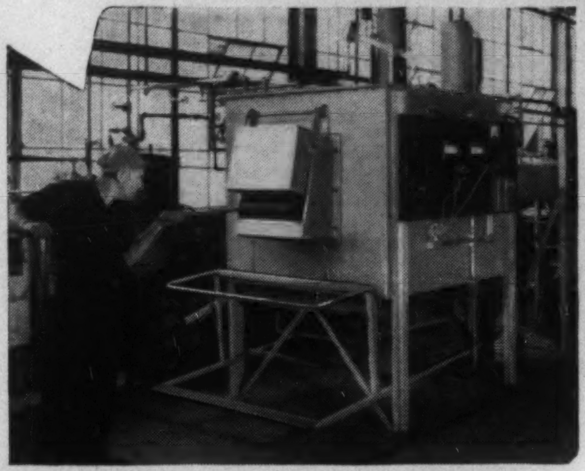
The demand for castings made in electric furnaces is on the increase, particularly those containing alloys. The metallurgical technique is important and complicated. On page MA 70 is a digest of an article by John Howe Hall, a recognized authority in this field, which can be read with profit by many steel foundrymen using electric melting furnaces. —E. F. C.

Hot Galvanizing

The composite (page MA 86) on hot galvanizing shows that the experts don't always agree. It reminds us of the composite reported by ***Fortune***, of the New Dealers' third term slogan as augmented by Wendell Wilkie: "Don't swap horses, or any part thereof, while crossing a stream." We might offer another: "We kept him out of war" as an amendment to the Wilsonian slogan. The amended and augmented form is usually both more interesting and more accurate than that coming from just one point of view.—H. W. G.

Magnesium Forgings

Magnesium products are very much in the limelight these days, a trend which is likely to expand. An interesting and informative digest of an article on forging magnesium alloys (page MA 89) will supply those interested with the salient points in a review from an English source of the developments in this field.—E. F. C.



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GENERAL ELECTRIC

160-90

editorial

Physics of Metallic Crystals

The metallurgist is always hopeful that the physicist will make it possible to understand the effect of atomic make-up on engineering properties, and ultimately to be able to predict and perhaps to control the properties.

The physicist speaks a special language, and is prone to think and to write in extremely abstract, mathematical terms, so that one not thoroughly grounded in atomic physics finds it impossible to follow the argument. It is evident that no real use can yet be made of what the physicist has so far untangled; nevertheless, for mental satisfaction, many metallurgists would like to be able to get some grasp of the ideas that the physicist has today on how the atoms hold themselves together in a metal crystal.

In current issues of the Bell System Technical Journal, starting with October, Shockley is publishing a series of articles under the title "The Quantum Physics of Solids." These articles are unusual in that instead of confining himself to mathematics solely, the author makes use of mechanical analogues, so that the layman can come closer to following the argument than in any other discussion we have seen. Even at that, the articles are not easy reading. But whether or not the reader is able to follow the argument in every detail, he will at least get a clearer picture of what the atomic physicist has in mind, and of the complexities that stand in the way of really evaluating the atomic forces in the crystals of any but the elements possessing only a few electrons.

As a more nearly painless discussion than any we have yet seen, these articles are worth calling to the attention of metallurgists interested in a bird's-eye view of the topic.—H. W. G.

Manganese

At a recent series of commemorative lectures on "Strategic Materials" during a celebration of the 75th anniversary of the founding in 1864 of the school of engineering at Columbia University, Reno H. Sales, chief geologist of the Anaconda Copper Mining Co., discussed "Manganese." Among other things he stated, in dealing with the steel industry, that from 850,000 to 1,000,000 gross tons of high grade manganese ore are necessary each year to assure the normal functioning of American steel industry. This seems a rather high estimate but in any event the quantity is large.

Not every one, at least not every thoughtful citizen, appreciates the fact that, if manganese were not available for introduction into steel, usually as ferromanganese, not a ton of good quality steel could be made. It is not generally realized that the great American steel industry is dependent on foreign suppliers for not less than 90 per cent of its needs. This fact is a serious matter in war time.

A recent statement from the Bureau of Mines says that stocks of manganese ore in bonded warehouses as of Dec. 31, 1939, amounted to 900,436 gross tons, largely in the hands of ferromanganese producers. This represents ore which had been imported up to Dec. 31 but which was still in bond. It is the total accumulation not only for 1939 but also for previous years. This would normally represent enough ore for one year's output of steel.

The rate at which such ore is coming into the country and is being used is shown by the imports for consumption which, for the first 10 months of 1939, were about 640,000 tons or 58,000 tons per month. This would mean about 698,000 tons for the year or less than a normal supply.

Under normal peace conditions, the status as represented above would be satisfactory. But, with a spread of the European war threatened, the present situation is precarious, especially when it is realized that most of our imported ore comes from Russia, India and the Gold Coast. The movement to store a supply has been set on foot but, at this writing (December), no ore had entered the country for strategic stockpile supplies. Were the war to spread and were our normal supplies interfered with, American steel makers would be faced with a decidedly serious problem for Brazil and Cuba could with difficulty fill our needs.

If ever there were a problem for research metallurgists, it is to find a substitute for manganese in steel making or a way to make steel without the use of manganese.—E. F. C.

Inland Research Scores Again

Ledloy—Another Metallurgical Achievement that Is Saving Money for Steel Users

Again, the pioneering of Inland metallurgical research has, in effect, put money into steel users' pockets.

The recently announced development of INLAND LEDLOY has enabled metal working plants to speed up their machining operations 30% to 60%. In terms of dollars, savings like the following examples are typical:

In the making of a case carburized worm shaft, $47.85 machining cost is being saved per ton of steel used.

The manufacturer of a socket ball control joint is saving $37.91 per ton by using Inland Ledloy 1120 instead of ordinary SAE 1120.

Finding ways of making better steel for each customer's purpose is the basis for Inland personal service. The occasional development of a new kind of steel, such as Inland Ledloy or Inland Hi-Steel (high tensile), merely emphasizes the extensive modern laboratory facilities which Inland makes daily available to all steel users.

Often but a small change in the surface characteristics of a steel sheet, or special control over its physical properties, makes a big difference in the costs and results of a forming operation; or the suggestions of an Inland engineer may help to save time and material in the use of structural steel.

More companies today than ever before are utilizing these special services to supplement their own technical staffs. We believe you would find this a worth-while practice to follow.

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highlights

Do you want to know what metallurgical engineers are doing, the world over? Look in the Metallurgical Engineering Digest. Here are some of the points covered by authors whose articles are digested in this issue.

Top-Charge Electric Furnaces

The advantages, particularly as to reduction in cost, of the top-charge electric arc furnace are discussed (page MA 128) and the statement is made that the increased use of arc furnaces is in part due to this improvement. Comparative costs of the top-charge and the older door-charge method are given.—E. F. C.

Desulphurizing with Calcium Carbide

The efficiency of alkalies like sodium carbonate or caustic soda for removing sulphur from blast furnace iron decreases as the desired sulphur content gets below 0.02%. According to Wood, Barrett & Holbrook (page MA 131), however, the use of calcium carbide as a desulphurizer permits the production of metal containing only 0.01% sulphur at a cost that is not excessive for this type of metal.—F. P. P.

Carbon in Steel

The rapid but accurate determination of carbon in steel, during the progress of a heat, is a necessity in successful steel operations. A new magnetic instrument, called the Carbanalyzer, used in an American steel mill, is described (page MA 164) as fast, convenient, accurate and relatively inexpensive.—E. F. C.

Pressing and Drawing Tools

A broad review of the subject of tools for pressing and drawing is given by a composite on page MA 134. Five articles on the selection, heat treatment and performance of tools for working various metals are assembled and correlated.—F. P. P.

Permanent Magnets

We are familiar with the permanent magnets of the cobalt-nickel type and now a German offers one having a copper base (page MA 154). It contains 60% Cu, 20% Ni and 20% Fe, and has some unusual properties.—E. F. C.

Some Ordnance Problems

Two articles digested in this issue are concerned with specific applications of metallurgical engineering to military equipment. Obrenski (page MA 143) discusses the heat treatment of steel artillery projectiles and Campbell (page MA 145) describes the development of manufacturing practices for brass cartridge cases.—F. P. P.

Calcium in Magnesium Alloys

Grain refinement and an increase in certain physical properties, particularly yield point, is demonstrated (page MA 154) to be the result of the addition of small amounts (0.10 to 0.13%) of calcium to magnesium alloys.—E. F. C.

Stack Cutting

An interesting fabricating method is that in which the oxyacetylene flame is used for cutting large numbers of identical shapes from thin steel plates, stacked and clamped tightly together. Details are given on page MA 140.—F. P. P.

Fatigue

The busy reader will find in a composite digest (page MA 152) a comprehensive view of German opinion on fatigue problems in aircraft. The Germans have had broad experience in aircraft construction and materials. Germane to this subject is an editorial in this issue which should be read.—E. F. C.

Gases and Metals

Many phases of the general subject of gases from, in, on, with and through metals are discussed in a composite (page MA 164), combining information from 9 articles published here and abroad.—F. P. P.

Welded Steel vs. Castings

Those interested in this question, concerning which there has been considerable discussion, will find a composite digest (page MA 150) which gives in condensed form the most recent information.—E. F. C.

FOR MELTING METAL

Alundum, Crystolon and Fused Magnesia Cements and Bonded Shapes

RESISTANCE to high temperatures, chemical resistance, and penetrability to molten metals and oxides—it is these features of Norton Refractories that are enabling them to cut lining costs in many types of furnaces for melting ferrous and non-ferrous metals. The several types of refractory materials and the different mixtures in each make it possible to exactly meet individual conditions.

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editorial

The Size Effect in Fatigue

Two phenomena disturb the students of fatigue and enter into the engineering application of fatigue data. Most determinations of endurance limit are made on rotating beam specimens with the tensile and compressive stresses equal and completely reversed in each cycle. Some determinations are made in "axial loading", push-pull tests, as on the Haigh machine, also with equal tensile and compressive stresses. Comparing the results of the two types of test, it is found that the axial tests commonly give lower results, sometimes by around 30 per cent low.[1]

In evaluation, by rotary bending, of the stress-concentration effects of a fillet of a given radius connecting a large diameter and a small diameter on a shaft, it is found that the effect does not appear to be one of mere geometry, for the larger the shaft diameters, the more serious is the stress concentration, as has been brought out by Peterson and Wahl.[2] That is, a small scale model behaves better than an actual large shaft.

It seems to be fundamental in fatigue that the nucleus for failure starts at the sorest spot, as Chapman[3] puts it, *i.e.,* wherever the relatively highest stress gets to work on the relatively weakest spot. The fatigue specimen responds to true local stress and the true local strength, regardless of what we calculate as average stress and average strength. Hence the ideas that there is anything occult about an axial vs. a rotary-bending application of stress, or in the behavior of large vs. small shafts, are open to challenge.

It is extremely difficult to set up an axial loading fatigue machine in which the specimens are uniformly loaded over the whole area and around the whole circumference. It took one of the best mechanics in the Bureau of Standards, months to align a Haigh machine so that it produced reasonably axial loading, when deviation from axial loading was evaluated by suitable and sufficiently sensitive extensometers. It will be uncommon indeed that an axial loading fatigue machine can be trusted not to produce, at some point on the circumference, something like 110 per cent instead of just 100 per cent of the calculated load. If so, the specimen has to respond to the true load and indicate a correspondingly lower endurance limit.

If there were anything about the type of loading that makes it imperative that lower endurance limits will result from truly axial loading of a truly homogeneous material, then axial loading results should *always* give lower results. However, both Irwin[4] and France,[5] using carefully adjusted Haigh machines, found some cases where axial loading gave just the same endurance limits as did rotary bending, amid other cases where the axial results were lower. Thus, while deviation from truly axial loading must account for some of the experimental discrepancy, it hardly accounts for all.

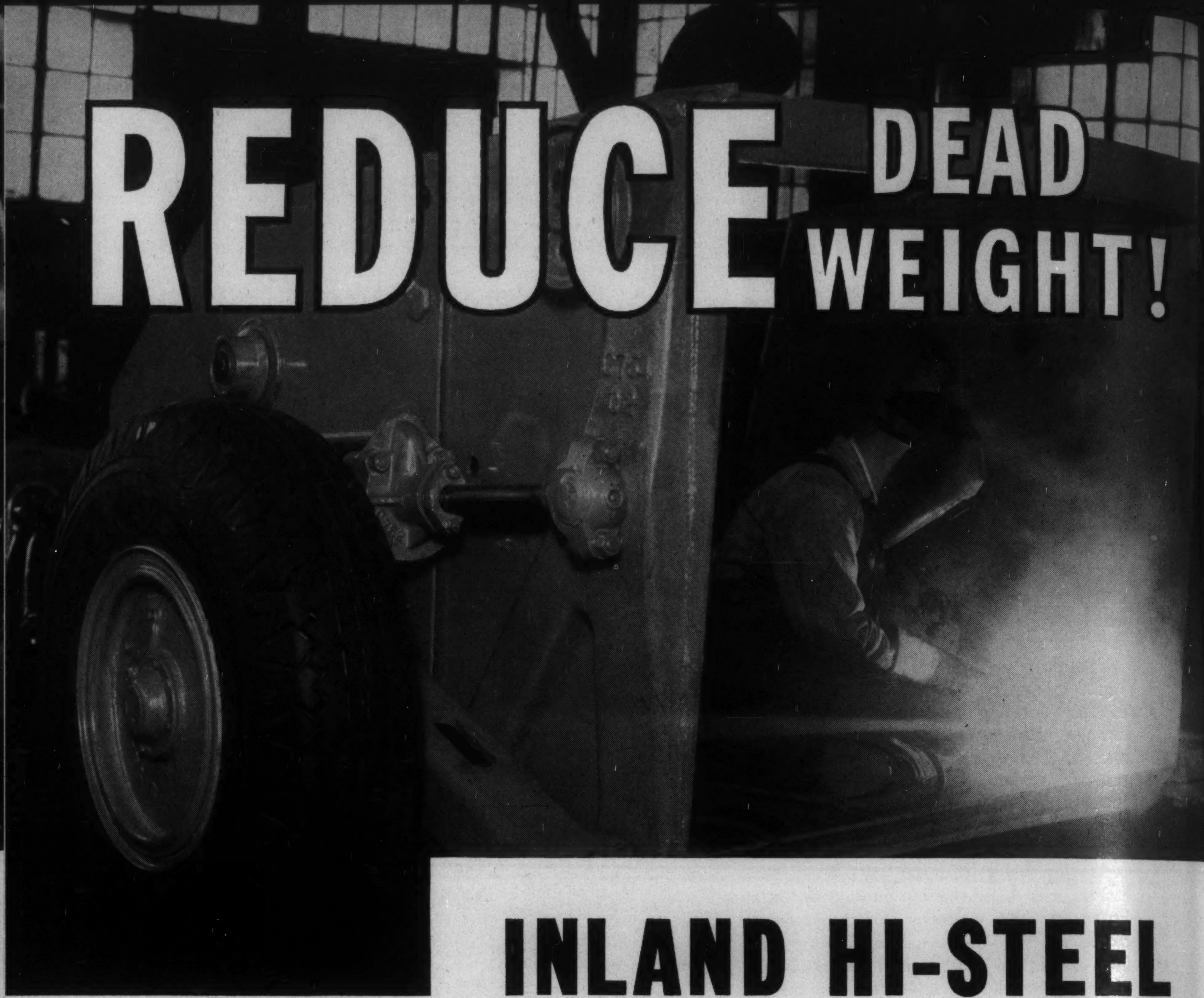
However, there is a further difference in the tests. Even though the Haigh machine specimen is of the same diameter (about ¼ in.) and the same radius of curvature (about 10 in.) as that used in the rotating beam tests, as was the case in the work of France, the axially loaded specimen has no neutral axis, the whole cross-section is uniformly stressed. In the rotating beam specimen only a tiny circle at the surface and at the minimum diameter, is stressed to the maximum calculated load. The stress falls off very rapidly from maximum at the surface to zero at the neutral axis, only ⅛ in. away. Longitudinally, the stress falls away more gradually from the minimum section toward the ends, but, as Horger and Maulbetsch[6] show, at a few hundredths of an inch away from the midsection, the stress is lower by a per cent or so, enough for the steel to know that the stress is lower.

Horger and Maulbetsch show S-N curves for rotary beam tests on specimens of the same diameter but different fillet radii. The endurance limits were identical, but the break in the curve occurred at a lower number of cycles the larger the radius, i.e., the larger the surface ring that was highly stressed.

Similarly, the more of the surface that is highly stressed, the lower would the indicated endurance limit tend to be, in tests of a material with interior stress-raisers or interior weak spots. Suppose we have one big balloon of 1000 sq. ft. surface and 1000 toy balloons, each of 1 sq. ft. surface. Make a single pin-prick in each case. The big balloon has failed, one of the toy balloons has failed, but the other 999 are all right. Thus, if we have sparsely distributed weak spots in a material, we may take fatigue specimens Nos. 1-999 from it, all of which behave well, while No. 1000 will fall below the S-N curve. With weak spots occurring more commonly, a sample of a dozen fatigue specimens may run into enough of them at the highly stressed volumes in the test pieces to show a wide S-N "scatter band" instead of an S-N

(Continued on page 94)

REDUCE DEAD WEIGHT!



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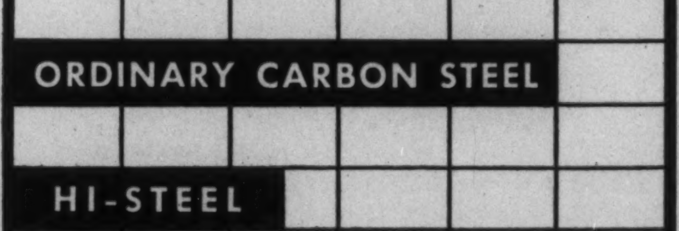

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highlights

Do you want to know what metallurgical engineers are doing, the world over? Look in the Metallurgical Engineering Digest. Here are some of the points covered by authors whose articles are digested in this issue.

Die Castings

A composite (page MA 218) which reviews three articles on die castings, whose use is growing rapidly, gives the busy reader the latest information on this topic. One article states that the automotive industry is the largest user of die castings. Two of the three articles are by Herbert Chase, an authority in this field.—E. F. C.

High Strength Irons

We know the A.F.A. is going to put us on their eternal black list for heading a composite digest on page MA 191 "Hight-Test Cast Irons" rather than "Cast Irons of Classes 35, 40, 50 and 60." But there's a war on abroad and we didn't want the title to sound like a new call to the colors. Anyway, the digest is a good review of methods of making such irons, and even if our terminology is officially "obsolete," we've a lot of company in our benightedness.—F. P. P.

Columbium vs. Hydrogen in Steel

May columbium be a cure for some of the ills ascribed to hydrogen in steel? A German research worker (page MA 190) reports that steels, purposely high in hydrogen, were dehydrogenized by the addition of columbium. In columbium-bearing steels the rate of hydrogen evolution increases with increasing columbium. The range of percentages suggested is 0.24 to 1.3 per cent columbium.—E. F. C.

Type Metal

A better type of type metal results from the additions of small amounts of cadmium and bismuth to the usual lead-tin-antimony alloys, according to Swarup and Prasad (page MA 224).—F. P. P.

Chromium Plating Molds for Plastics

General practice in the plastics industry is to chromium plate the molds for resistance to wear and corrosion. Unplated molds are etched by the plastic. Other advantages and reasons for plating molds and dies are outlined in a brief composite (page MA 215) of two articles.—E. F. C.

Sand or Permanent Mold Castings?

Some points of comparison between sand castings and permanent mold castings in aluminum alloys and in copper alloys are given in a composite on page MA 224. One of the authors finds "lower cost" for permanent mold castings, but no information is given on the number of castings about which this may be true and below which it is not true.—F. P. P.

Alnico from Powdered Metals

A possible practical commercial application of powder metallurgy is the production of Alnico permanent magnets which are now largely a cast product. That this method of production is possible is described (page MA 204) by a General Electric representative who discusses the process and the properties of the product. Future metal powder costs are a factor as to whether or not this process will replace casting.—E. F. C.

Slag Control

A good appraisal by Herty of the status of open hearth slag control and recent information from several other sources are reviewed in a composite digest on page MA 190. F. P. P.

Magnesium Alloy Castings

Increasing importance is being assumed by magnesium alloys in the aeronautical and other industries and demand for the metal has advanced sharply. One of our valuable composites (page MA 192) reviews two articles on precautions to be observed in the production of best quality castings and on melting technique claimed to improve castability and mechanical properties of the sand-cast alloys. —E. F. C.

Piston Ring Surface Treatments

Cast iron piston rings may have their surfaces treated by a variety of processes, from soft-metal coatings to lacquerings. Englisch (page MA 198) engine-tested several, and found little difference among the surface treatments tested, although all were better than no treatment at all.—F. P. P.

Why Gillette
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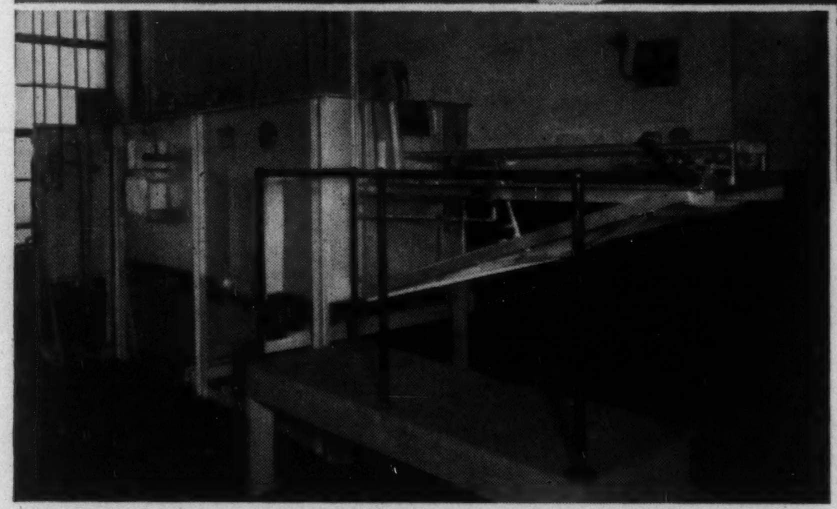

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Whiskers are tough; so these electric razor cutter heads must be sharp and must stay sharp. Whiskers are small, too; so these cutter heads must fit together accurately. Exacting requirements these—heat-treating small parts which involve such close tolerances—but a G-E scale-free hardening furnace gives the precise treatment desired.

Officials of the Gillette Safety Razor Company knew that this furnace would do the job before they installed it in their modern new factory. They had worked closely with G-E heating specialists and had treated their samples beforehand in the G-E Industrial Heating Laboratory at Schenectady.

This installation is typical of what G-E engineers can do to help you get the results you are after. Whether you heat-treat tiny parts to the tolerances of a whisker, or turn out tons of big bolts per hour, General Electric can supply you with scale-free hardening furnaces that do the job exactly as you want it done, and do it economically, too.

GENERAL ELECTRIC

160-91

editorial

New Blood

From time to time we have editorialized about the desirability of putting new blood into the working groups of technical societies. When a new job has to be done for which a new committee is needed the tendency is to pick the members from those who have already made a reputation in that field and class as experts. But these men are invariably so busy that their function is primarily that of a figurehead. As new responsibilities arise, they have to pass them on to their assistants. So it often happens that the members are but figureheads, their constructive work lies merely in giving advice which, for lack of time, is often mere snap judgment.

The youngsters do the work, but the setup is such that they don't get much credit. They would do better and more enthusiastic work if they had more direct responsibility and more direct credit, and the committees would not be weighted down with inactive, more or less honorary members. A nonworking member of a committee soon becomes an abomination, even though at the outset it appeared that his name lent dignity to the committee.

A move in the right direction is being made by the American Society for Testing Materials. The executive committee has sent the following to the members of the standing committees:

> The A.S.T.M. will best grow and fulfill its functions of preparing timely specifications and test methods if there is a constant infiltration of young men into the Society's work. The A.S.T.M. provides a unique opportunity for young technologists to work with those more experienced on specific projects. This permits the younger engineers to acquire the art of those more experienced and to broaden themselves in the direction of dealing with other people. The necessity to negotiate and compromise, to cooperate, and to combine ideas of many people has always been and will ever continue to be one of the prime functions of engineering. An unusual opportunity is provided by the A.S.T.M. for training in this direction.
>
> It is recommended, therefore, that in all those cases where it is feasible, the members of the Standing Committees attempt to bring, or send, younger members of their staff to the Society's meetings. It is felt that these younger men can be given, in those cases where it is desirable, some specific work or responsibility and this should, by easy stages, lead to important benefits not only to the junior engineer but also to the Society. In the case of company and sustaining members this can often be brought about by arranging to have these young men represent the company on active standing committees and subcommittees.

Other societies might well follow this example. —H. W. G.

Alloys of Iron

A splendid and impressive example of the value of cooperation between industry and research is found in the progress report for ten years of the Alloys of Iron Research.

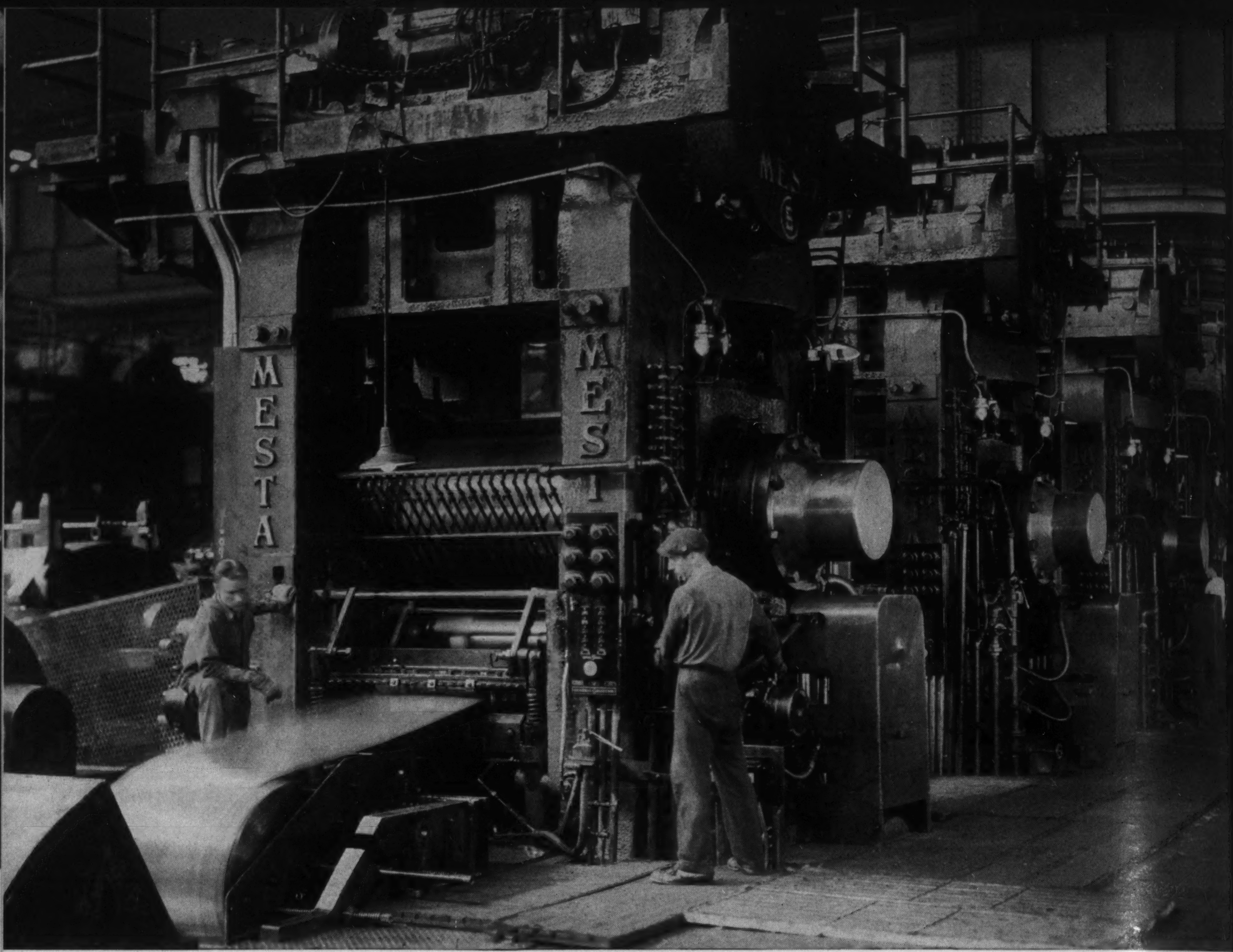
At a cost of nearly $272,000 and with the cooperation of 88 manufacturers, research organizations, technical societies and federal bureaus, "hitherto inaccessible information has been assembled from the technical literature of many nations." Ten monographs on iron and some of its alloys, 5,630 pages in all, have been completed as the result of the reading of about 10,000 papers and 20,000 abstracts, covering international progress since 1890. An excellent editorial staff, with the valuable assistance of industrial metallurgists, has performed a monumental job.

An interesting fact in the report is that, of 6,218 papers utilized in the preparation of the monographs, Americans contributed 43.5 per cent, with Germany second at 25.5 per cent and England third at 19.1 per cent.

An accurate monetary value of this work would be impossible to measure. The cost, distributed among some 50 large producers and users of alloy steels and cast irons, is really small when one takes into account the benefits derived and the wasted efforts avoided.

Four additional monographs are planned, and it is hoped that every financial and other aid will be forthcoming to bring this important work to a conclusion. The committee's recommendation that hereafter an annual appropriation of about $15,000 be made so that the monographs may be revised and brought up to date at regular intervals is strongly seconded. Developments in metallurgy are rapid and correlated data of this nature should be kept up to date.—E. F. C.

(Continued on Page 124)



ARE YOU MEETING COMPETITION with Today's Steels?

Competition does not begin at point of sale—that is where it ends. Competition starts when an idea is conceived—and it cannot be separated from design, selection of materials, production cost, and service tests. Therefore, no matter what results you may have had in the past, you cannot afford to disregard the competitive advantages offered by today's steels.

Inland has on file case after case of faster production, fewer rejections, finer finished products, and thousands of dollars added to profits by the use of the more recently developed Inland Ledloy that saves from a few dollars to $50.00 or more per ton of steel machined—Inland Hi-Steel that builds stronger yet lighter—and, Inland specially processed sheets that help users meet competition by their superior workability and finer finish.

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highlights

Do you want to know what metallurgical engineers are doing, the world over? Look in the Metallurgical Engineering Digest. Here are some of the points covered by authors whose articles are digested in this issue.

Gases in Steel

The question of gases in steel, particularly hydrogen, and the effect of these on the product has been a problem for many years. One of our composites (page MA 252) gives the results of two Swedish investigations, one on hydrogen and one on nitrogen in steel.

That there is renewed interest in this subject is emphasized by an extensive research in progress in the United States. In this issue there will be found the first instalment of a correlated abstract on "Hydrogen, Flakes and Shatter Cracks in Steel."—E. F. C.

Electroplates in Engineering Design

The utility of electroplates as metal-forms for engineering uses, rather than as protective or beautifying coatings, is reviewed in a composite on page MA 280.—F. P. P.

Bearings and Lubrication

All readers who have problems in this field will want to read the "composite" on page MA 278. More needs to be known about the "how come" that a good lubricant should attack the bearing, but if the attack is too severe then the bearing is a failure due to corrosion.—O. E. H.

Steel Welding Electrodes

The choice of electrodes for welding a "simple" material like steel isn't a casual matter any more, as a composite on page MA 265 demonstrates. Some helpful hints for selecting the right electrode in certain cases are given. One interesting suggestion is the use of coated arc-welding electrodes as gas-welding rods.—F. P. P.

Iron Powder

Two articles, one American and one German, on sintering iron powders are digested in a composite on page MA 268. There is always keen interest in any contributions on powder metallurgy. The two authors do not agree on all points—the American finds that pressure has only a slight effect on density, while the Germans find it to have a decided effect on tensile properties.—E. F. C.

Galvanized Roofing in Quebec

Having a galvanized roof on a boathouse at our own camp in Quebec, the comments in this article (page MA 280) are of personal interest. There are at least two factors that lessen the corrosion rate in Quebec over that in the bulk of the U. S. The air is entirely free from coal smoke over most of Quebec. The temperature is below freezing for a greater proportion of the time, leaving fewer days when dew or fog produce a moisture film over the roof. So the conditions of service are such as make acceptable material that might have too short a life in less favorable locations.—H. W. G.

Copper Fireboxes

Locomotive fire boxes of copper have demonstrated their superiority in savings in operating costs in all countries except in the United States where steel is preferred (page MA 284). Recently copper with 1 per cent of elements such as arsenic, nickel and silicon has been used because of its better strength.—E. F. C.

Lead Cable Sheathing

A new method of manufacturing lead cable sheathing, based on bottom-filling of the lead press cylinder and refinement of the lead with sodium, is described by Reinitz and Wiseman (page MA 274). Their claims for a superior product are politely attacked by others.—F. P. P.

Leaded Al-Mg Alloys

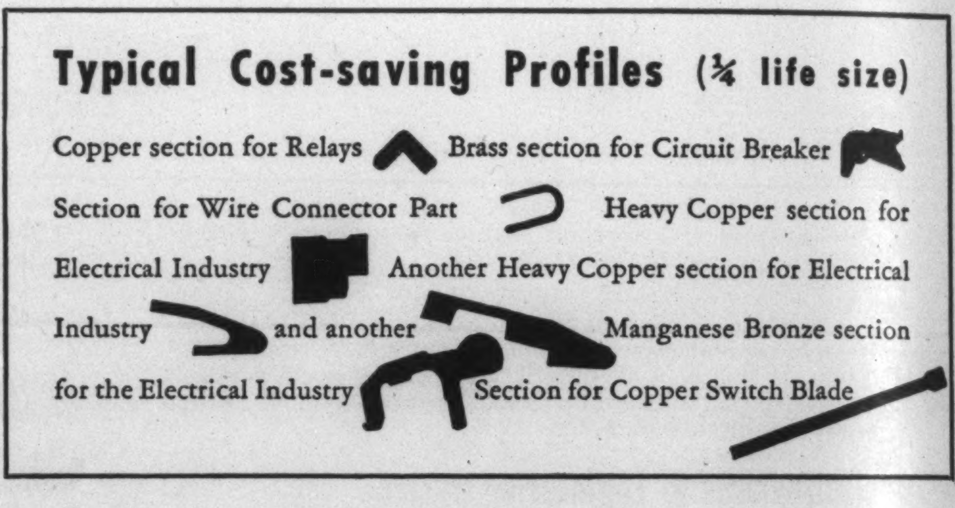
Of interest because of its possible analogy to "Ledloy," the lead-bearing open-hearth steel for free-cutting, is the addition of lead to Al-Mg alloys to increase the free-cutting properties of these alloys. Results of some German experiments (page MA 288) are of considerable interest. —E. F. C.

Liquid Steel Temperatures

A thermocouple of tungsten and molybdenum (page MA 294) has been developed by two Swedish scientists for taking the temperature of steel in the basic open-hearth furnace. The authors believe that temperature control by such thermocouples should insure greater uniformity of production.—E. F. C.

PROFILES—

NEEDN'T BE HANDSOME TO CUT DOWN BILLS!



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The Specialist

Our office at Battelle opens into the periodical room of the library, where, month by month, copies of some two hundred technical and scientific journals go on the shelves. These contain a queer hodgepodge of useful and useless information, varying from accounts of pioneer experimental work or summaries of engineering principles worked out by years of experience, to copied articles we have seen before and press releases of the propaganda type. They range from short notes on some new kinks that a mechanic has found useful and wants to pass on to fellow workers to abstruse discussions of highbrow theory choked with mathematical formulae that may mean something to a handful of other theorists studying allied problems.

But whatever they are, they represent hours, often years, of thought on some particular specialty. Every correlated abstract represents a good many man-years, which, summed up, would amount to the whole life time of one man, or even of many men. As we leaf over the journals, looking for items that will set off a train of thought leading to the development of a new research problem or a better attack on an old one, we often think of the man-hours behind the pages, and wonder what course of events brought about the specialization.

Comment is often made on the commonness of the occurrence by which a discovery or invention is made simultaneously by workers widely separated. Yet with the present dissemination of information, the same group of facts and conditions, which set the stage for a new development, are equally known to many. As well as wondering why several minds mull over the same set of facts and arrive at similar conclusions, we might reserve a little astonishment for the divergency of interests which allows so many people to specialize in so many different lines.

It would be interesting to trace the various factors acting on a given mind, and the way that mind has reacted to the various impulses which have finally set it on a certain course. Many of these factors are accidental; a man was offered a certain job on a certain date, when some minor incident had put him in the mood to consider a change, or, in college, a professor picked a thesis topic out of thin air, the student who wrote the thesis got interested in that field and without exercising any real volition, found himself in an industry in which the background resulting from this accidental interest could be utilized.

Supply and demand doubtless govern the broad grouping in some degree, but chance rules in most of the individual cases. For example, take one of the very specialized sciences, such as horology. We shall probably want watches fifty years from now, and if we do, we will be able to purchase them, but what combination of chance and of purpose will select the personnel, yet unborn, of the staff that will design and build them? The personnel of the geophysical exploration firms, prior to the introduction of special college courses in that field, must have been gathered together from people whose direct preparation for such work was slim but whose minds happened to be intrigued by just that type of problem.

The science of aerodynamics requires a particular type of engineering brain, a type that one would not have expected to be very plentiful. Yet when the demand arose for such engineers, the brains appeared, and mostly in the heads of very young men.

In metallurgy, the detailed problems that need the services of a specialist are becoming very numerous Some of them call for a combination of metallurgical understanding with an unusual degree of knowledge of a technique that may previously have been considered distinctly outside of metallurgy. Spectrographic analysis, electron diffraction, photo-elasticity, fall into such a category. Surface hardening by induction and by flame, nitriding, electro-polishing and hundreds of other fields have developed, each of which demands, and gets, the attention of at least a few specialists.

It would be difficult to suggest a subject that does not have a sufficient number of devotees to allow staging a symposium or round table of surpassing interest to a few kindred spirits, and one that will be listened to with tolerance, if not with understanding, by others ever hopeful for a useful new tool, method, or idea.

It's good that human nature makes people interested in different things. If all gentlemen preferred blondes, the biological results would be unsatisfactory. If everyone had our own degree of enjoyment in seeing the shores of our favorite Canadian lakes

(Continued on Page 156)

5 Reasons for Using...

Ryerson Certified Steels

1 Every pound of steel in Ryerson stock is certified, prime quality. No seconds are ever carried. Ryerson has built up complete stocks of these better steels in every classification—steels made to narrow, close-range specifications that assure better working qualities. For example: Ryerson Hot Rolled Bands will bend flat on themselves either with or against the grain; Continuous Mill Sheets in Ryerson stock are rolled from only the best part of the coil to make sure of flatness, accurate gauge and size; structural shapes and plates meet A.S.T.M. specifications not simply manufacturers standards; machine and carriage bolts have cut—not rolled—threads, etc.

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PREVIEW

of the Forty-Third Annual Convention of the

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Atlantic City, N. J.

JUNE 24 to 28, 1940

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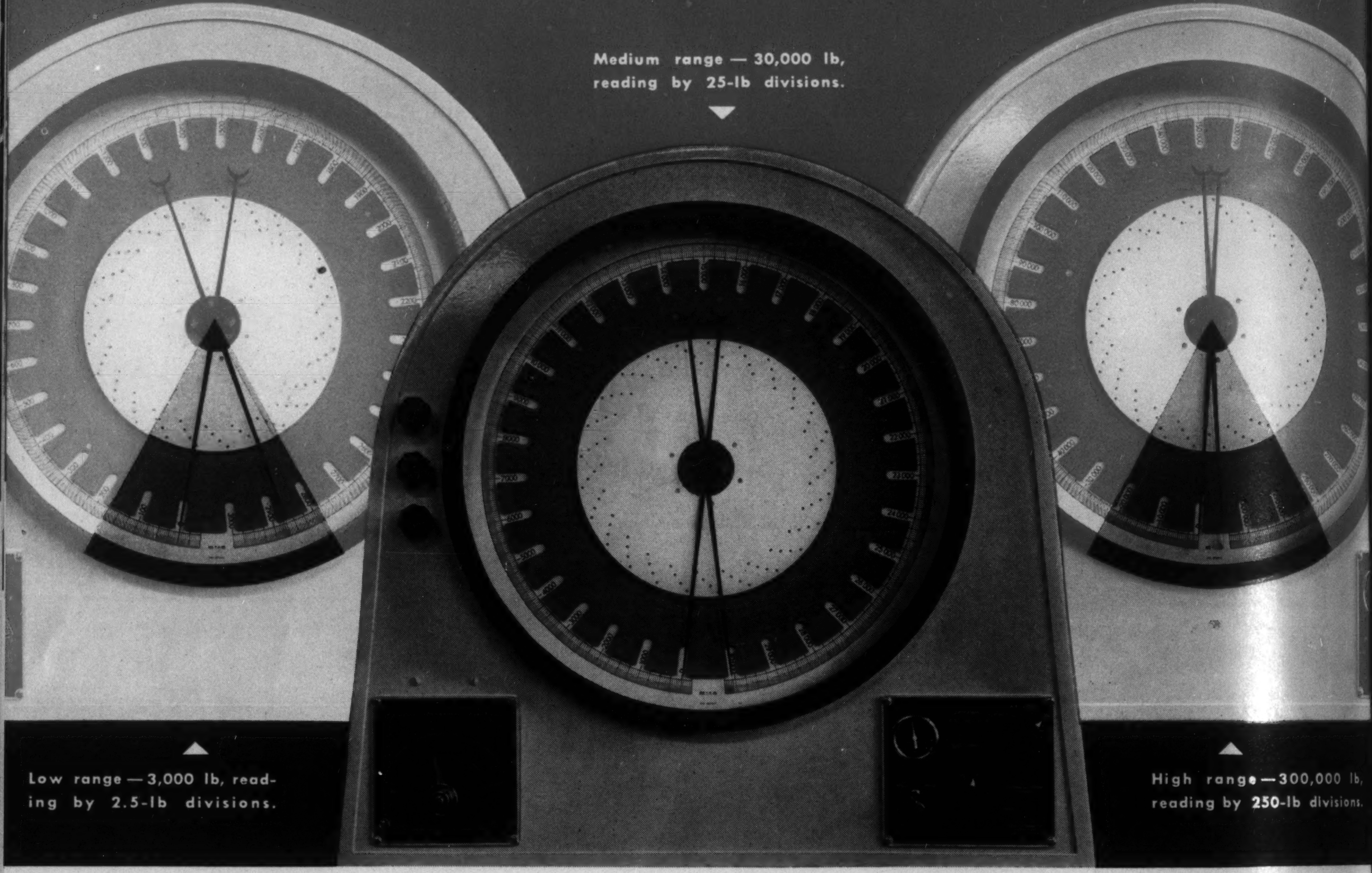

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Introduction

The American Society for Testing Materials will hold its 43d annual convention this year at Chalfonte-Haddon Hall, Atlantic City, N. J., June 24 to 28. Last year in the same place an exhibition of testing apparatus and related equipment was held, but there will be no such display this year.

Besides the usual array of technical sessions, four symposiums have been scheduled: Significance of the Tension Test in Relation to Design; Spectrographic Analysis; Tools of Analytical Chemistry; and Industrial Water. There will be the usual sessions on Steel, Ferroalloys and Metallography; Corrosion and Iron; Fatigue and Corrosion-Fatigue; Effect of Temperature and Creep; Radiography, Non-Ferrous Metals; Fuels; and Methods of Testing. These subjects will be covered by technical papers and committee reports.

The opening session will be held Tuesday morning, June 25, Monday being devoted largely to committee meetings. Features of the opening session will be an address by the President, H. H. Morgan; a report of the Executive Committee by C. L. Warwick, secretary-treasurer of the society; recognition of 40-yr. members; award of honorary memberships; and introduction of newly elected officers. A special feature will be an address on "Materials Standards in Industrial Preparedness" by Lieut.-Col. William C. Young, of the planning branch of the office of the assistant secretary of war.

The Edgar Marburg Lecturer this year—the 15th lecture—will be delivered by P. H. Bates, chief, clay and silicate products division of the National Bureau of Standards, Washington. His subject will be "Portland Cement—Theories (Proved and Otherwise) and Specifications."

The third photographic exhibit will be a feature of this year's meeting. A committee of prominent photographers in the Philadelphia area, headed by J. P. Mudd of The Midvale Steel Co. is in charge.

The tentative program of the technical sessions having to do with metals and the metal industry will be found on other pages.

Tentative Technical Program

TUESDAY, JUNE 25

Morning

Report of committee E-9 on research.

Report of committee E-10 on standards.

Annual report of executive committee, by C. L. Warwick, secretary-treasurer.

"Materials Standards in Industrial Preparedness," by Lieut-Col. William C. Young, planning branch, office of Secretary of War.

President's address by H. H. Morgan.

Introduction of new officers.

Afternoon

RADIOGRAPHY

Report of committee E-7 on radiographic testing.

"Reduction of Secondary Radiation and of Excessive Radiographic Contrast by Filtration," by Herman E. Seeman, Eastman Kodak Co.

"Observations on Radiography at 1,000,000 Volts," by Carlton G. Lutts, United States navy yard, J. T. Norton and J. G. Trump, Massachusetts Institute of Technology.

Evening

SYMPOSIUM ON WATER

Report of committee D-19 on water for industrial uses.

"Introduction to Symposium on Problems in Classification of Natural Water Intended for Industrial Use," by F. N. Speller.

"Reporting the Results of Water Analysis," by Robert C. Adams, United States Naval Engineering Experiment Station.

"A Review of Data on Relationship of Corrosivity of Water to Its Chemical Analysis," by V. V. Kendall, National Tube Co.

"Measuring Scale-Forming and Corrosive Tendencies of Water by Short-Time Tests," by Everett P. Partridge and G. B. Hatch, Hall Laboratories Inc.

"A Method of Measuring Corrosiveness," by J. H. Walker, Detroit Edison Co.

METHODS OF TESTING

Report of committee E-1 on methods of testing.

"An Investigation of Effect of Rate of Strain on Results of Tension Tests of Metals," by Paul G. Jones and H. F. Moore, University of Illinois.

"Speed in Tension Testing and Its Effect on Yield Point Values," by Lawford H. Fry, Edgewater Steel Co.

Report of committee E-3 on chemical analysis of metals.

Report of committee E-2 on spectrographic analysis.

"Quantitative Spectrographic Analysis of Steels," by S. Vigo, Watertown Arsenal.

Report of committee E-8 on nomenclature and definitions.

WEDNESDAY, JUNE 26

Morning

SYMPOSIUM ON SIGNIFICANCE OF TENSION TEST IN RELATION TO DESIGN

"Introduction," by John M. Lessells, Massachusetts Institute of Technology.

"The Tension Test," by C. W. MacGregor, Massachusetts Institute of Technology.

(Continued on page A15)

highlights

Do you want to know what metallurgical engineers are doing, the world over? Look in the Metallurgical Engineering Digest. Here are some of the points covered by authors whose articles are digested in this issue.

Powdered Nickel

Those interested in powder metallurgy should read the composite on new uses of powdered nickel on page MA 320. German investigators report that this form of nickel can be used to produce nickel sheet for cladding from sintered-nickel billets and also to make solid nickel-chromium alloys.—E. F. C.

Steel Castings in Weld-Fabrication

We've always stood in envious awe of those gifted individuals that can reconcile conflicting viewpoints, practices or policies—the "great compromisers" of everyday life, so to speak. Whole-hog-or-none is a stupid attitude in anything, so here's our freshest orchid to those enlightened souls like Krejki (page MA 350), who promote the combined use of castings and welded plate in the construction of a single machine, instead of touting either exclusively. —F. P. P.

Brake Drums

Most brake drums for the automotive industry are cast in sand molds but casting them centrifugally in a permanent mold (page MA 318) is said to produce more uniform castings both in size and balance, according to the experience of a Canadian foundry.—E. F. C.

Polonium in Spark Plugs

As little as 0.0002% Po added to the usual spark plug electrode alloy effects a noticeable improvement in sparking performance, according to Dillon (page MA 353). Polonium-tipped electrodes also seem very promising.—F. P. P.

Blast Furnaces, Domestic and Foreign

The importance of the blast furnace to the steel industry of any nation is not always fully appreciated. A composite (page MA 314) gives the reader a broad view of the size and importance of the blast furnaces in the United States, Great Britain, Germany and some other countries. Next to the United States, Russia probably has the greatest number of large modern stacks, and new furnaces in that country are almost exclusively based on American design. —E. F. C.

Testing

Since this issue is dedicated to the A. S. T. M. and its annual meeting, it is appropriate to call attention to the diversity of "testing" digests in section 4 (pages MA 355 and 356). Stress measurement, torsion creep testing, electroplate porosity estimation, corrosion testing, metallographic etching, radiographic inspection, and bend-tensile testing are all discussed.—F. P. P.

A New System of Firing

Convection heating is regarded as faster and more uniform than radiation heating for lower temperature operations such as tempering (page MA 323), according to a Surface Combustion engineer. A description of the new firing system (Conjecto-Firing) is given.—E. F. C.

Iron Castings in Machine Tools

The importance of the modulus of elasticity in the engineering design of cast iron machinery is emphasized in a composite on page MA 350, which also gives much attention to internal stresses and their removal.—F. P. P.

Bright Annealing of Stainless Steel

According to a German research (page MA 334) protective atmospheres containing carbon monoxide are not suitable for bright annealing high-chromium steels. Hydrogen is therefore about the only available gas, with cracked ammonia the most desirable source of hydrogen. The problem of the absorption of nitrogen by high-chromium steels is discussed.—E. F. C.

Platinum-Clad Nickel Alloys

Increasing industrial interest in the applications of platinum-clad nickel alloy sheet, screen, tubing and wire is indicated by Carter (page MA 352).—F. P. P.

Magnesium Alloys

Information on two methods for pre-treating and finishing magnesium alloys is found in a digest of two articles on page MA 341. These supplement present methods of protecting such alloys from corrosion, always a problem in their growing importance and application.—E. F. C.

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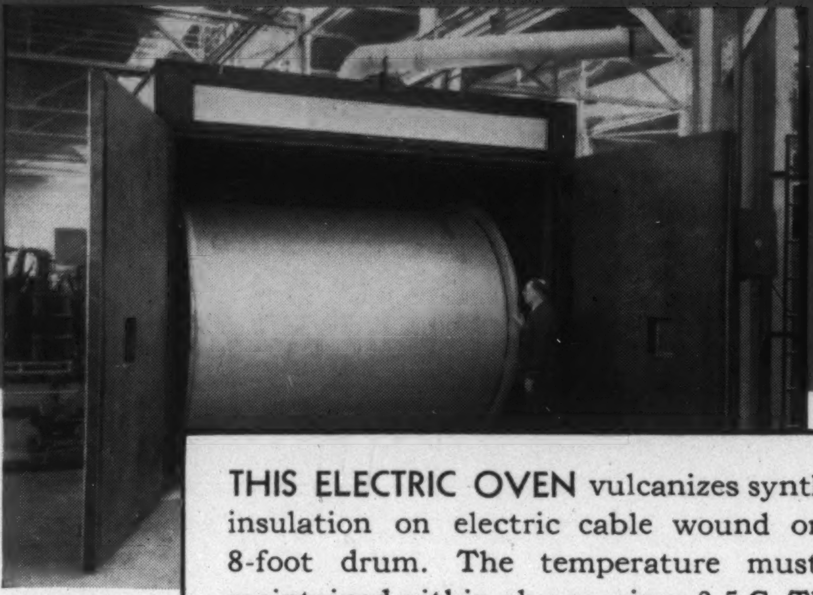

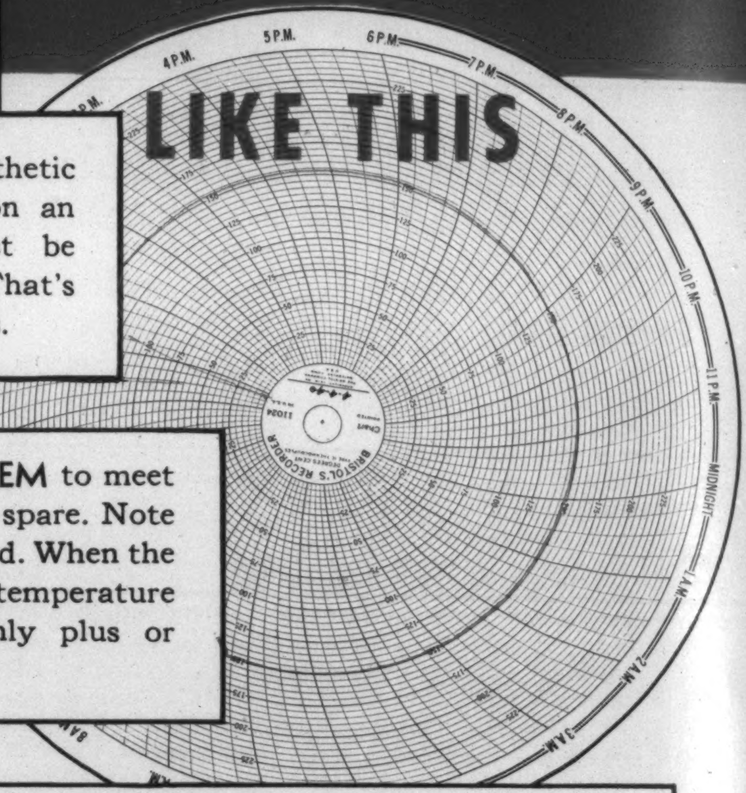

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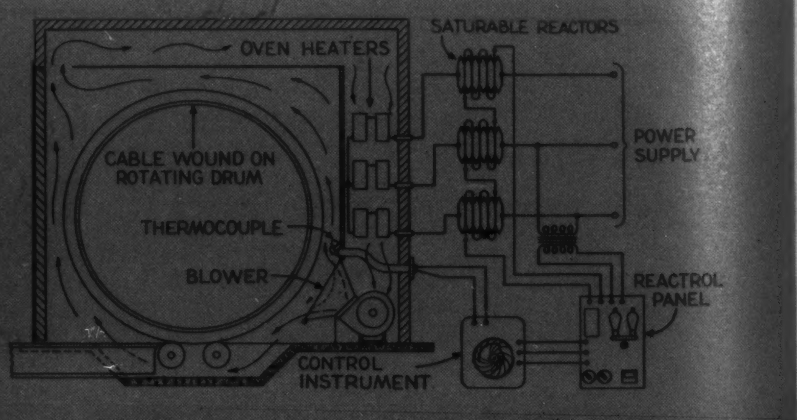
OPERATES THIS WAY—The throttling action of the G-E Reactrol system automatically varies the voltage to provide a continuous flow of power to the oven heaters. Their temperature fluctuates only slightly, and the rapidly circulating air is heated evenly.



GENERAL ELECTRIC

675-4

Wanted—Words

The old terms "elastic limit" and "proportional limit" are passing out of use, nor are attempts often made to measure what these values were meant to express.

From the point of view of static loading there is probably very little need for an attempt to determine a "truly elastic" range. Design on the basis of yield strength and a factor of safety seems to handle the problem. When such data are wanted, a figure of this nature can be had by using the "proof load" method. Originally a proof load test was a "go" or "no go" test in which a specified load was applied, then released, and the gage length measured to see if it had stretched. If it had *not* stretched more than the allowed tolerance, the specimen passed the proof. But to tell at what stress it did begin to stretch, the specimen had to be reloaded at a higher stress, and again measured after release of load, and so on, till the specified amount of set was obtained. This was tedious and expensive.

Determination of the stress for a given set by proof load methods did not become popular although this proof-load still appears in certain Federal specifications. These methods have been and can be used to determine "a stress for a predetermined set." But "proof strength" is not a good terminology.

For many years it was customary, when a tension test had been run with an extensometer and a complete set of readings taken, to plot the stress strain curve, squint along it, jab a pencil at the place where the plot seemed to begin to curve off the straight line, and call this the "proportional limit"—the end of the straight line proportionality between stress and strain. But the position of the point was vastly affected by sensitivity of the extensometer, the care taken in aligning the specimen, and the scale and method of plotting used. If you used a Berry strain gage, you got one thing; if a Martens, Huggenberger, or Tuckerman extensometer, you got another, and there was no certainty that anybody else, using those instruments would get just what you did.

When these obversational discrepancies became understood, it became obvious that "P.L." reported in John Jones' paper didn't mean anything in particular, and even research workers ceased to report or observe the value, contenting themselves with reporting "yield point."

Thereupon the A.S.T.M. rose to state that darned few *metals have yield points*, indeed, that nothing much has one except soft steels, and urged that the term be dropped in favor of "yield strength," the stress at which a *given amount* of permanent deformation, large enough to be measurable with crude equipment, is produced. This given amount must be stated, or standardized, and thereafter implied in the term. As an amount which, on soft steels, gave about the same value as the old drop of beam or dividers method, 0.2 per cent, or 0.004 in. in 2 in., was ordinarily used. By this step it became possible to compare, fairly rationally, the load-carrying-ability-without-too-damn-much-deformation values of different materials, even though their stress-strain diagrams were of different types.

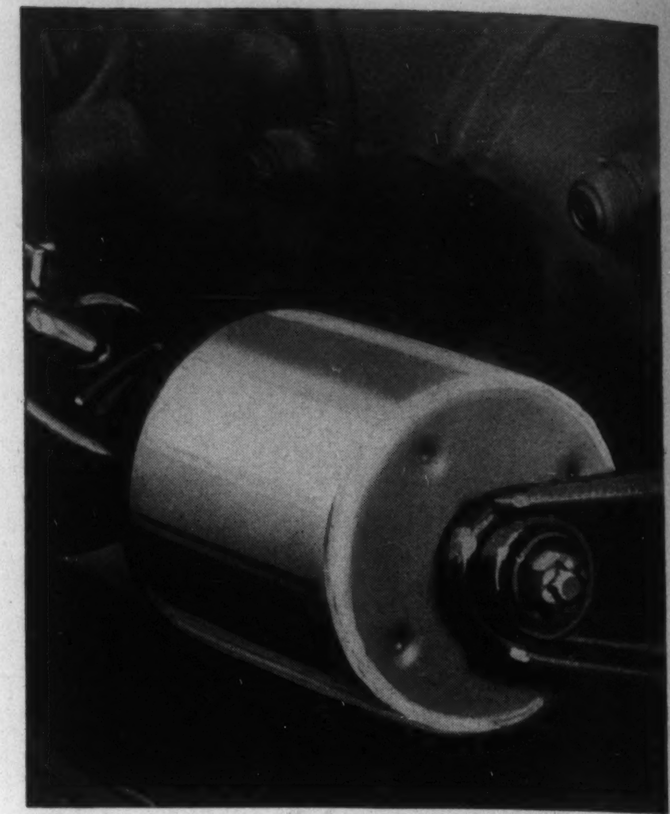
In order to get an estimate of this value on the run, without having to release the load and really measure the set, the "offset" method was devised, as described in A.S.T.M. E8-36. In using this method it is assumed that the deviation of the stress strain curve from a straight line under a given stress is a reliable measure of the permanent set produced by that stress. Fortunately for the users of this method, an offset of the order of 0.2 per cent in the ordinary structural materials is usually accompanied by a permanent set of the same order of magnitude. The "yield strength (0.2 per cent offset)" or "Navy yield strength" or any other "yield strength" with an offset of this order of magnitude stated or clearly implied, furnishes for the ordinary structural materials a useful measure of the "load-carrying-ability-without-too-damn-much-deformation." It is intelligible as a term and reproducible enough as a matter of testing to be satisfactory for many engineering uses.

But the yield strength value is only one point on the stress-strain curve, and we are becoming increasingly curious as to much smaller degrees of plastic action. Instead of worrying about the elastic properties from the point of view of desiring to have no permanent set, however minute, we are beginning to wonder whether we ought not to develop materials in which there is minute plastic action at a low stress, and this without materially dropping the yield strength below that of present materials. Or, put in another way, we may want a stress-strain diagram very slightly curved below the yield strength, a diagram of the type shown by cast iron.

The diagnosis of the failure of the heat-treated wire in the Mt. Hope bridge brought out, as one likely factor, in the failure, the refusal of the heat-treated wire to seat over the loops as well as cold-drawn wire because of a higher "proportional limit"

(Continued on Page 188)

REJECTIONS CUT 2/3 on difficult draw!



Production cost went down when Inland Hot Rolled Sheets were used to form this vacuum cylinder.

Heart of the newest Automatic Gear Shift is this vacuum cylinder, a 4-inch diameter cup, drawn to a 4½-inch depth. And the call is for 8000 parts per day.

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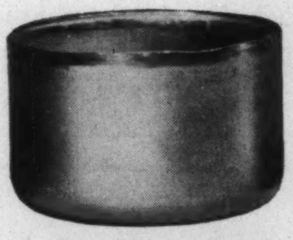
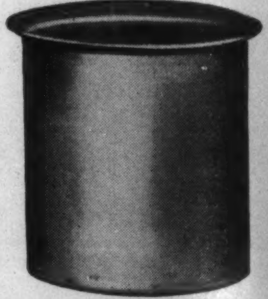
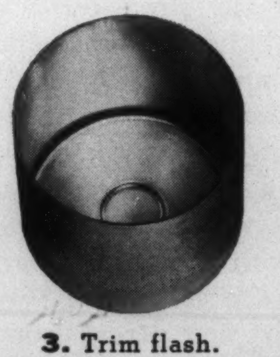


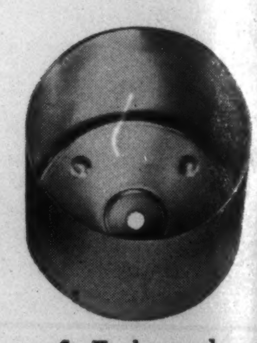
1. First draw. Blank and cup.



2. Second draw. Draw to 4½ inches.



3. Trim flash.



4. Embossed, punched and drilled.

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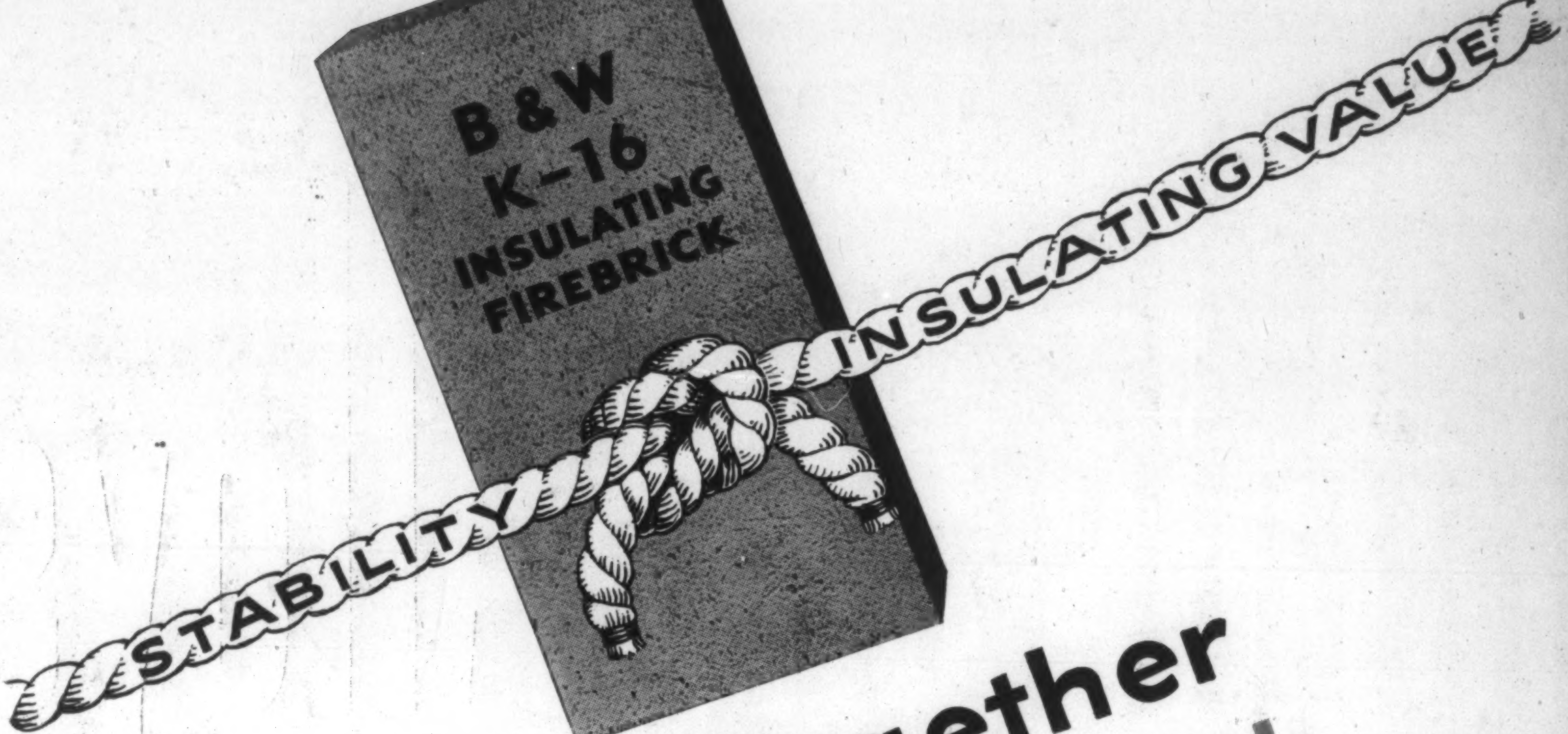
PRODUCTION · FABRICATION · TREATMENT · APPLICATION

JUNE 1940


B & W
K-16
INSULATING
FIREBRICK
STABILITY
INSULATING VALUE

Tied Together For Economical Backing-Up Insulation

B&W K-16 Insulating Firebrick represent the nearest approach to the ideal insulator, for backing up where interface temperatures do not exceed 2000 F.—because they combine exceptional insulating value with the stability of a fired-clay refractory.

B&W K-16's are made of special Georgia kaolin by a process developed and used exclusively by Babcock & Wilcox. Unequalled by any other insulating material in stability, they retain their structure, show negligible shrinkage, and possess high hot-load-bearing capacity.

Great stability, tied together with high insulating value, provides significant economies in backing-up insulation. In the case of B&W K-16's, this means savings as high as 40 per cent in the cost of insulating material for a given heat-flow.

B & W
K-16
INSULATING
FIREBRICK
BULLETIN R-18
BABCOCK & WILCOX

Write for new Bulletin R-18, which gives engineering data on B&W K-16 Insulating Firebrick.

THE BABCOCK & WILCOX COMPANY
Refractories Division
85 Liberty Street **New York, N. Y.**

R-99

BABCOCK & WILCOX

• NO MORE NIGHT-OWL HOURS AT THE PLANT FOR WILSON SINCE HE LET US GO TO WORK FOR HIM

THIS theatre party is in the nature of a celebration for Jack Wilson and his charming wife. It's their first outing together in the past six weeks. Six weeks that Wilson has spent glued to his job, long past closing time, poring over cost sheets and production records night after night.

What happened was this. Wilson is production manager for a prominent "parts" manufacturer. Everything seemed to be going along fine. Nice orders were coming in. Costs, he thought, were right in line with competition.

But one day Wilson got a nasty shock. He happened to overhear some figures on his chief competitor's production that made him sit up and blink. Although this competitor's equipment was practically identical with Wilson's, he was getting production between tool settings that Wilson's plant had never even approached.

So Wilson went to work. And how! He practically turned his plant upside down. Every machine, every operation and every operator in the shop was checked and rechecked. But without result.

Then one of our men happened to drop in. Wilson told him the whole story and asked for suggestions. A change of steel was recommended. A trial order of U·S·S Controlled Steel was put through.

Production between tool settings jumped 700%! Where they formerly processed between 4,000 and 8,000 pounds of parts per day, they now process 8,000 to 11,000 pounds. Output practically doubled.* Yet the steel costs no more than before. No wonder that Mr. and Mrs. Wilson feel like stepping out.

We welcome the chance to show you what U·S·S Controlled Steels can do for you. Here are plain carbon steels for forming, forging, heat treating and machining in which *all* quality factors are definitely predetermined and kept uniform in shipment after shipment. Invite us to demonstrate their money-saving possibilities.

**These are actual production figures. In this case history, only the names are fictitious.*

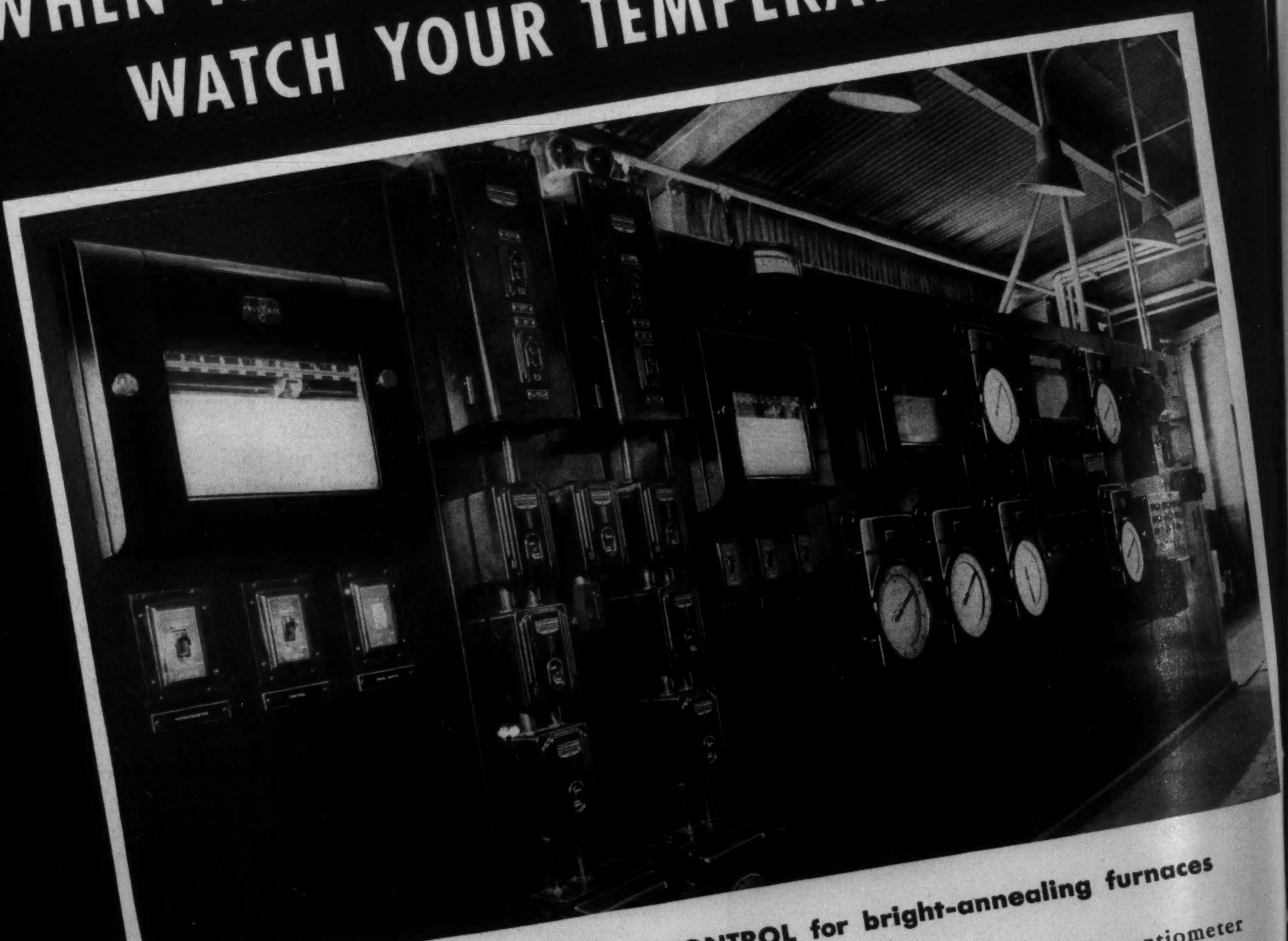
USS

UNITED STATES STEEL

STEELS

CORPORATION

EVERY DEGREE MUST "*Keep in Line*" WHEN THESE BRISTOL'S PYROMETERS WATCH YOUR TEMPERATURES

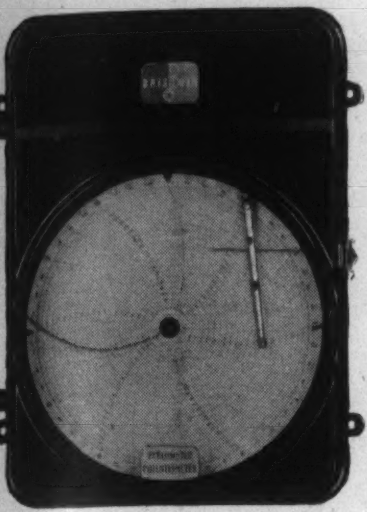


HERE, ALSO, IT'S BRISTOL'S CONTROL for bright-annealing furnaces

In order to protect the quality of its stainless steel sheets, this steel plant in the Pittsburgh district controls the temperatures of bright-annealing furnaces with precision accuracy by means of Bristol's Wide-Strip Potentiometer Pyrometer Controllers and Bristol's Indicating Dial Type Pyromaster Potentiometer Controllers.

In addition, Bristol's Wide-Strip Pyrometers are installed for continuously recording the temperatures in important zones in the furnaces which they serve.

FOR EXACTING TEMPERATURE MEASUREMENT AND CONTROL
Bristol's Potentiometer Pyrometers offer many advantages that money can't buy except in a Bristol's

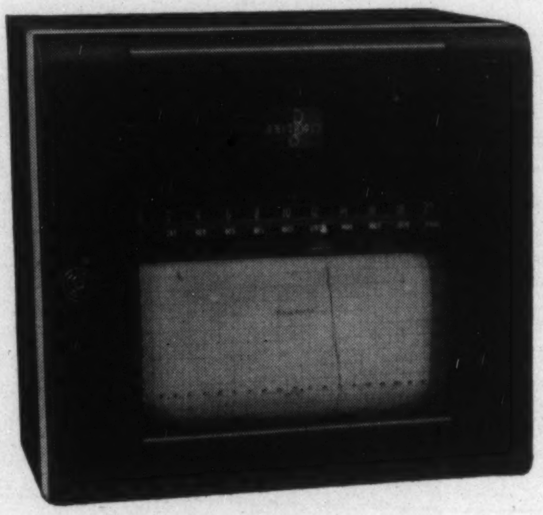


ROUND-CHART PYROMASTER POTENTIOMETER PYROMETER

Unaffected by vibration. It can be mounted in *any* position. ☆ No oiling. Working parts are easily removed or replaced. ☆ Parts run only when necessary,—not continuously. ☆ Galvanometer is of pivot design. No suspension ribbons. ☆ Extreme accuracy is easily obtainable. ☆ Your own men can service the Pyromaster successfully, quickly, economically.

WIDE-STRIP POTENTIOMETER PYROMETER

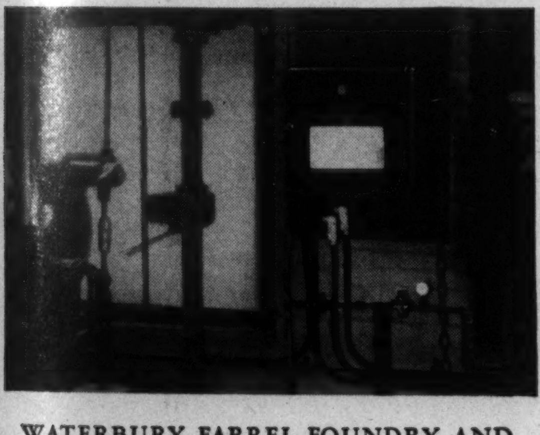
Extra wide 12¾" chart. ☆ Large easy-to-read scale. ☆ Automatic standardization. ☆ Automatic cold junction compensator. ☆ Extreme accuracy.



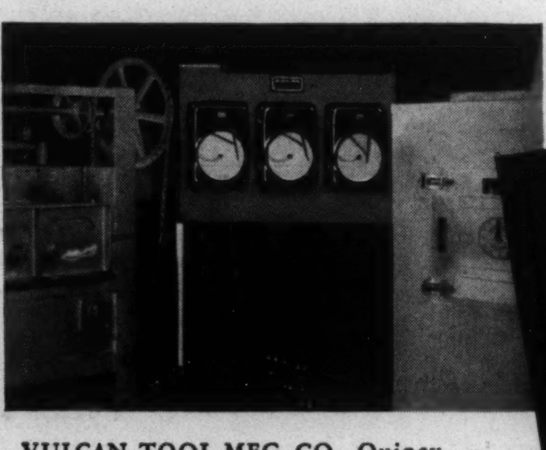
To the engineer who appreciates the importance of having constant, unvarying control over furnace temperatures regardless of operating conditions, Bristol's Potentiometer Pyrometers offer many worth-while benefits. Thermocouple and radiation types,—for temperatures up to 3600°F. The coupon below brings you complete information. Mail it today.

THE BRISTOL COMPANY • WATERBURY, CONNECTICUT

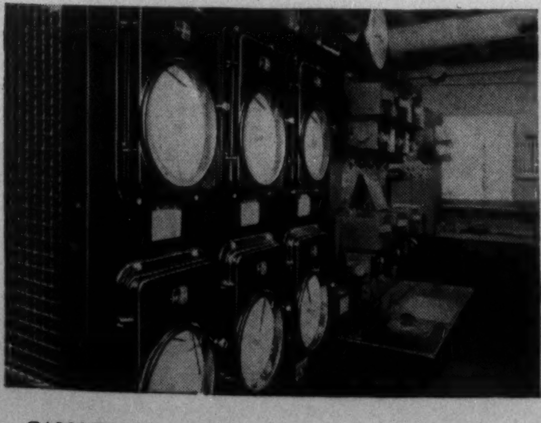
FINE PERFORMANCE your best index of Bristol's accuracy



WATERBURY FARREL FOUNDRY AND MACHINE CO., Waterbury, Conn. This Bristol's Wide-Strip Controller has given extremely satisfactory close control of forging furnace temperatures for many years.



VULCAN TOOL MFG. CO., Quincy, Mass. Three Bristol's Pyromaster Controllers are providing precision temperature control of two hardening furnaces and one tempering oven.



CANADIAN ACME SCREW AND GEAR, Ltd., Toronto, Ont. Close-up of panel on which are mounted Bristol's Pyromaster Controllers for regulating temperatures in heat treating furnaces. According to this plant, Bristol's are "accurate, dependable, satisfactory".

YORK SAFE & LOCK CO., York, Pa. Shown at right is Bristol's Pyromaster Controller serving a car bottom furnace for stress relieving welded structures for anti-aircraft gun mounts. At the left is a Bristol's Millivoltmeter Pyrometer with a twelve-point switch.

BRISTOL'S
TRADE MARK REG. U.S. PAT. OFF.

THE BRISTOL CO., WATERBURY, CONN.
Please send me the literature I have checked below

- ☐ Cat. 1452Y. Wide Strip Potentiometer
- ☐ Bul. 507Y. Pyromaster Pyrometer Con
- ☐ Bul. 488Y. Millivoltmeter Pyrometer
- ☐ Bul. 155Y. Radiation Pyrometer

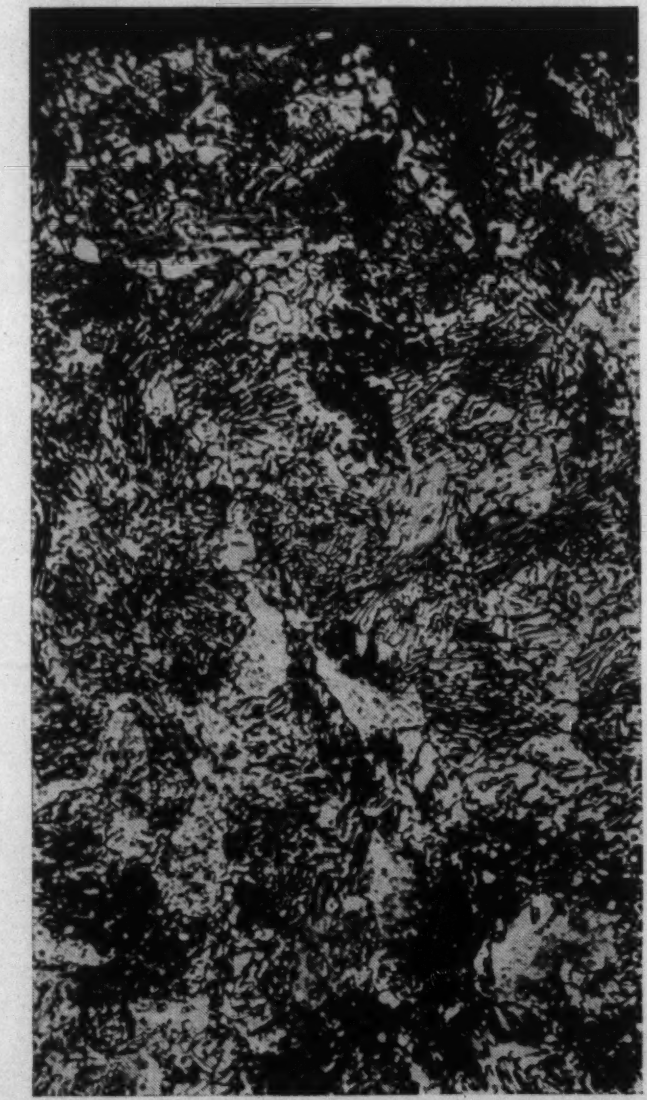
NAME..

ADDRESS......................................

....

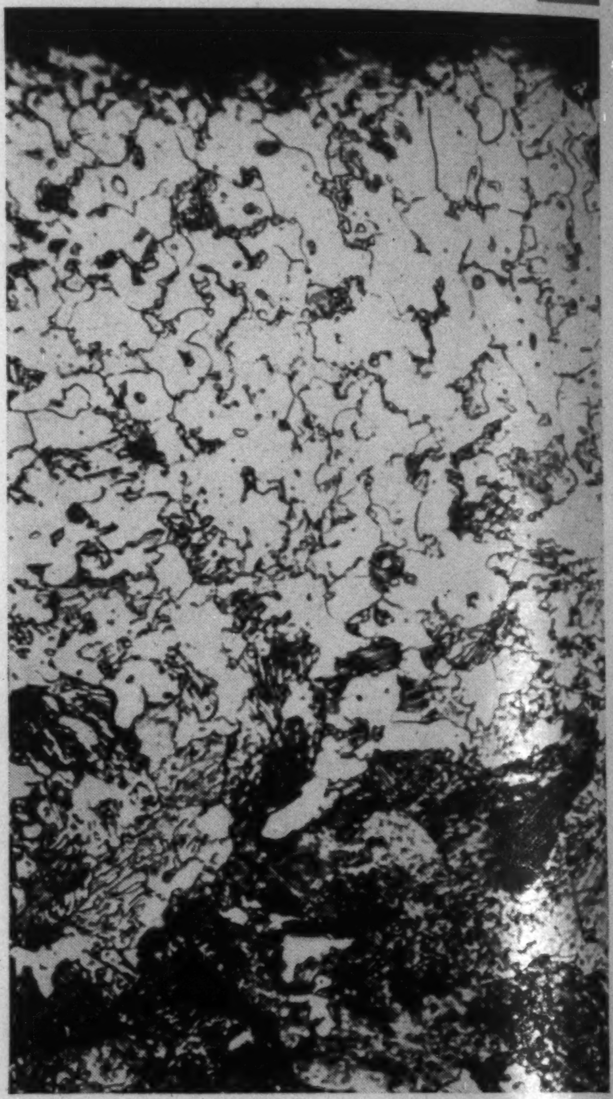
PROOF THAT ENDOGAS

HARDENS EVEN S. A. E. 1095 WITH NO DECARBURIZATION



ENDOGAS SCALE-FREE HARDENING SHOWS NO "DECARB" OF S.A.E. 1095
This micro-photograph proves conclusively that no decarburization takes place when S. A. E. 1095 steel is scale-free hardened in the Westinghouse ENDOGAS atmosphere. Treatment was for one hour at 1500° F.

...YET ORDINARY SCALE-FREE HARDENING DECARBURIZES TO .005 INCH
This is what happened to the same steel—S.A.E.1095—when hardened for the same period, at the same temperature, in an ordinary scale-free gas atmosphere. Upper white portion reveals decarburization to approximately .005".



S. A. E. 1095 is just one of many steels considered difficult to treat, which ENDOGAS hardens without a trace of decarburization. Yet ENDOGAS is not expensive—is easily obtained using either natural or manufactured city gas as a base. Costly driers and CO_2 removal equipment are not required.

J-10199

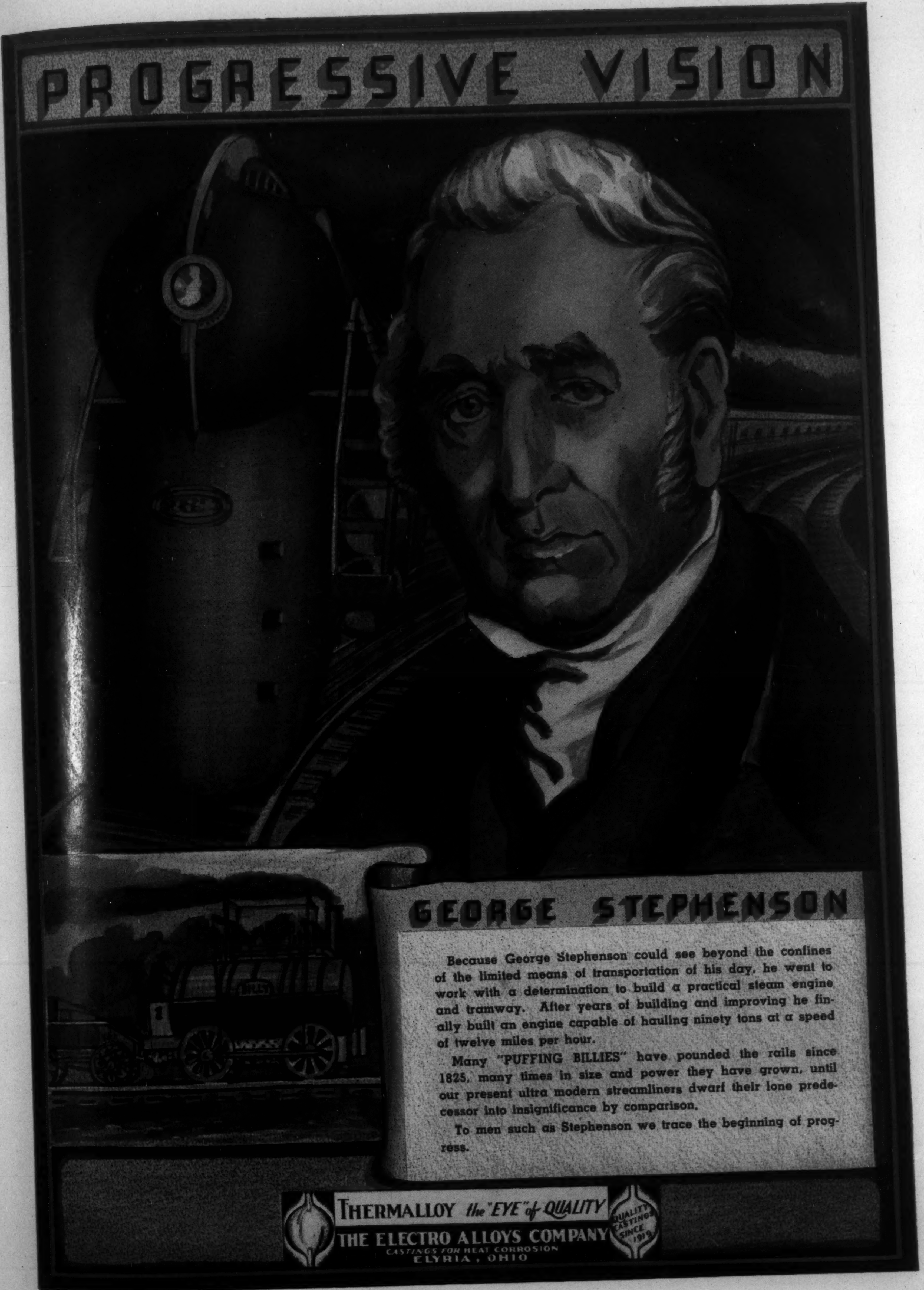
Complete technical data is now available on how to apply this low cost method of hardening and annealing under production conditions. Write for it today.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
DEPT. 7-N EAST PITTSBURGH, PA.

Westinghouse

WESTINGHOUSE ELECTRIC

Complete Heat Treating Equipment



PROGRESSIVE VISION

GEORGE STEPHENSON

Because George Stephenson could see beyond the confines of the limited means of transportation of his day, he went to work with a determination to build a practical steam engine and tramway. After years of building and improving he finally built an engine capable of hauling ninety tons at a speed of twelve miles per hour.

Many "PUFFING BILLIES" have pounded the rails since 1825, many times in size and power they have grown, until our present ultra modern streamliners dwarf their lone predecessor into insignificance by comparison.

To men such as Stephenson we trace the beginning of progress.

THERMALLOY the "EYE" of QUALITY
THE ELECTRO ALLOYS COMPANY
CASTINGS FOR HEAT CORROSION
ELYRIA, OHIO
QUALITY CASTINGS SINCE 1919

MIDVALE *Craftsmen*

IN rough "hogging down" jobs, where ordinary calipers are used instead of micrometers, it's a good deal like the housewife peeling potatoes. The careless one slashes away regardless, the one with pride in her work peels a very thin skin. Even in rough work a craftsman takes pride in doing it neatly, efficiently, economically—and that pride travels along into the finished product.

THE MIDVALE COMPANY • NICETOWN • PHILADELPHIA, PA.

OFFICES: ***New York • Chicago • Pittsburgh • Washington • Cleveland • San Francisco***

ARISTOLOY
STEELS

A STATEMENT OF POLICY

The Copperweld Steel Company offers and is now shipping, under the trade name "ARISTOLOY," the finest alloy steels that can be produced in a modern steel plant under the guidance of men who helped build the alloy steel industry. The plant has ample capacity; but quality, not quantity, will be our constant aim. This aim is consistent with our 25 year record in the manufacture of other high-grade Copperweld Steel products at our Glassport, Pennsylvania mills. The name "ARISTOLOY," derived from "ARISTOS" (Greek root word of "Aristocrat") is significant of this policy.

S E Bramer
President

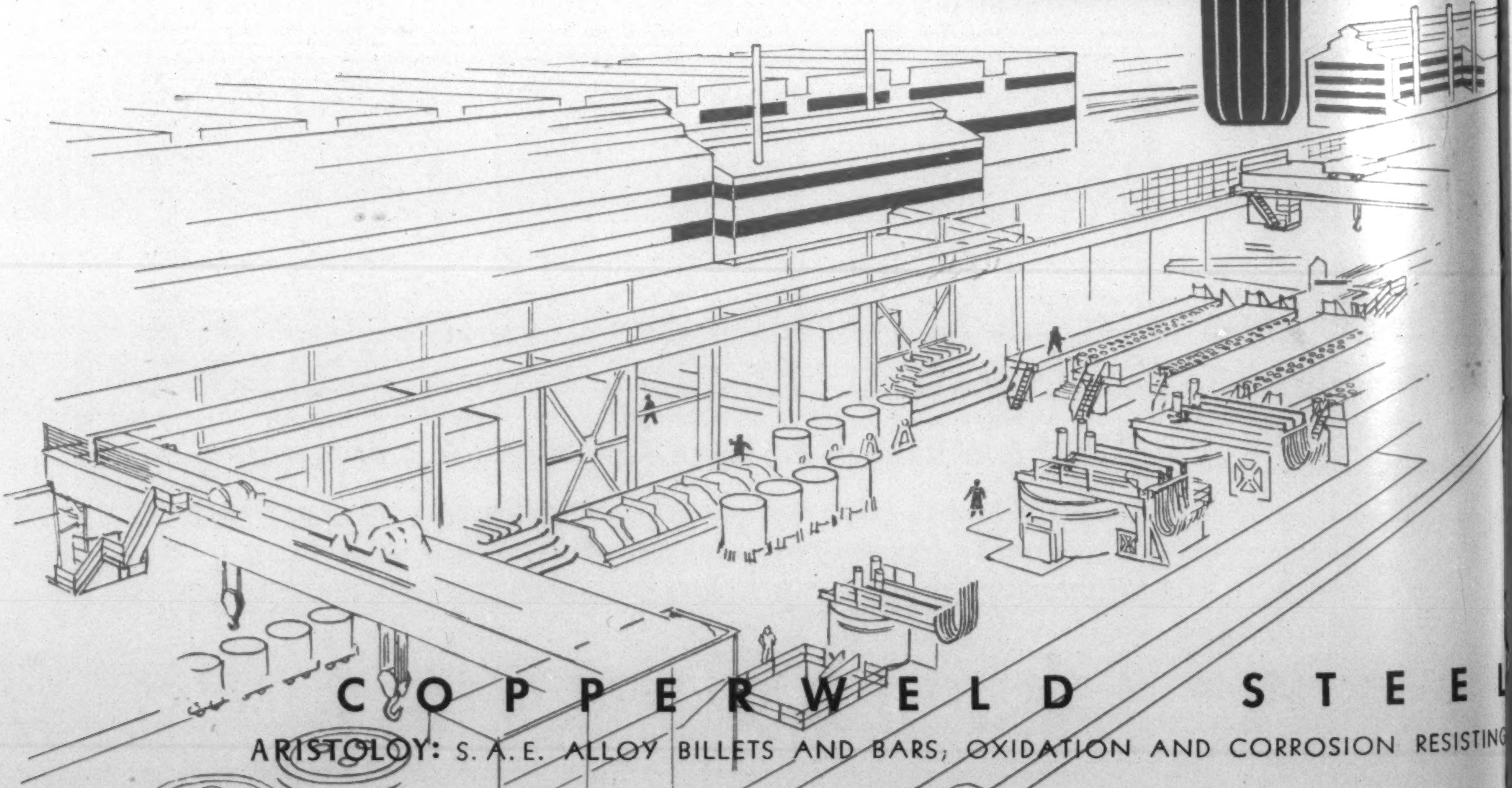
COPPERWELD STEEL COMPANY · Warren, Ohio

These Men HAVE BEEN MAKING A

Men, plant and capital are requirements for the manufacture of any product—and *men* come first. These "Aristoloy" steel makers, who have been making steel for you for a quarter of a century, now have a new plant, designed as they have always wished a plant to be—and operating under the policy of quality and customer-satisfaction first. The experience and character of these men is your assurance that "Aristoloy" consistently will be the kind of steel you need — delivered when you want it.

35 Years
FREDERICK J. GRIFFITHS
Executive Vice President

ARISTOLOY
STEELS



COPPERWELD STEEL

ARISTOLOY: S. A. E. ALLOY BILLETS AND BARS, OXIDATION AND CORROSION RESISTING

IN ALLOY STEELS FOR YOU FOR 25 YEARS

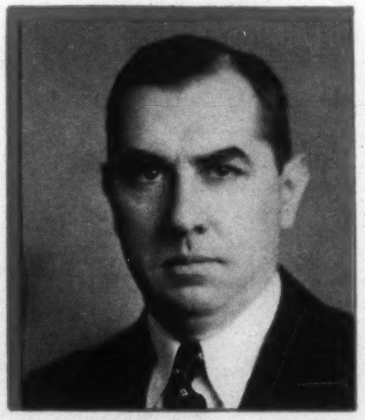
27 Years
SIDNEY D. WILLIAMS
Vice President & in Charge of Sales

31 Years
C. W. HOLMQUIST
Works Manager

20 Years
NORMAN L. DEUBLE
Assistant to Vice President

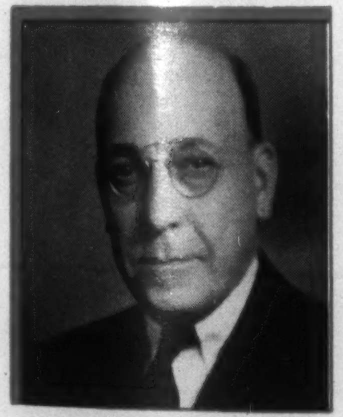
42 Years
PAUL LINDBERG
Superintendent of Rolling Mills

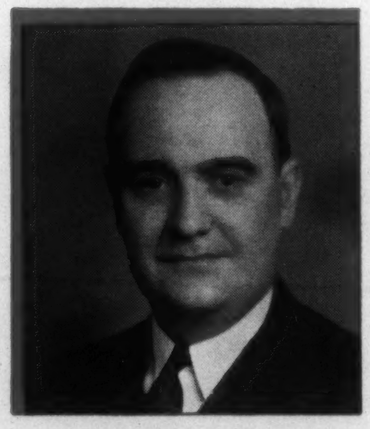
14 Years
W. J. BUECHLING
Chief Metallurgist


19 Years
FLOYD STROUP
Superintendent of Melt Shop

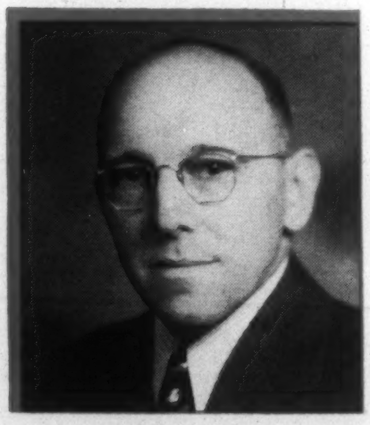
16 Years
ROY F. LAB
Chief Chemist

18 Years
JOHN B. FORMET
Asst. Supt. of Rolling Mills


31 Years
W. C. MORGENSTERN
Assistant Chief Engineer


28 Years
JOHN P. SMITH
Chief Engineer

18 Years
J. RUSSELL PENMAN
Production Manager


30 Years
H. F. PESCHEL
Chief Roll Designer

COMPANY *Warren, Ohio*

STEELS; TOOL AND SPECIAL STEELS; AIRCRAFT QUALITY STEELS; STAINLESS STEELS

TRANSEPT BLDG
BAR AND ROD MILL
FINISHING MILL
MACHINE SHOP
MILL DRIVES
BLOOMING MILL
MATERIAL BINS
CROP CONVEYOR
LABORATORY
FURNACES
MELT SHOP
CROP BINS
TEEMING PLATFORMS
INGOT CONVEYOR
STRIPPER
HOLDING PIT
EQUIPMENT
ARISTOLOY STEELS

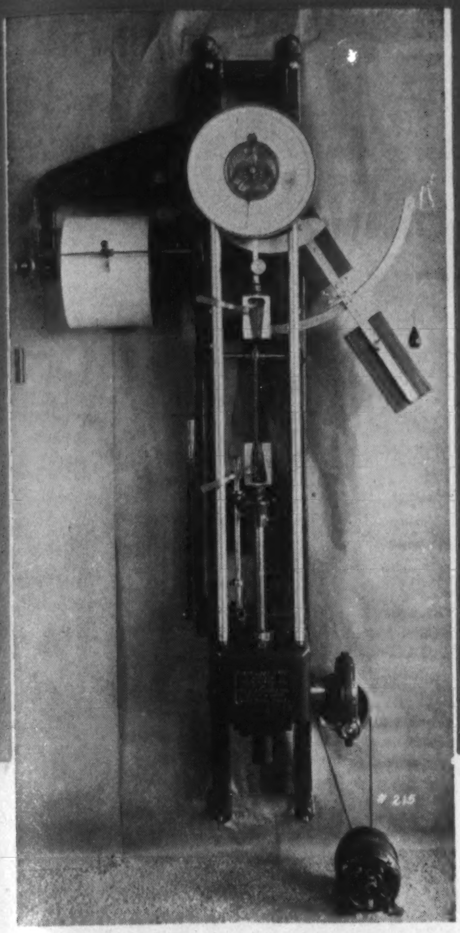
Direct production "flow" features this new plant layout. Material moves from bins to charge 25 ton melting furnaces in 15 minutes. Oversize transformers contribute to a rapid melting down of the furnace charge, resulting in more time for the all important refining period. Hot-top molds are teemed at stationary stands immediately adjacent to the melting furnaces. A hydraulic stripper places stripped ingots on a direct conveyor to the blooming mill furnaces. Blooming mills and rod mills are all in direct-line arrangement with the finishing and shipping departments. Pneumatic tubes speed test samples from mill and furnace stations to the modern new laboratories, and written test results are flashed back by telautograph.

There is cleanliness and order and plentiful air, space, and daylight in all of the 320,000 square feet of floor space — and all production floor space is completely served by overhead cranes.

Ideal operating conditions, and "direct-flow" plant layout, enable the makers of Aristoloy Steels to make every bit of their long experience count in their real job of making the kind of steel you need—and to deliver it when you want it.

COPPERWELD STEEL COMPANY, Warren, Ohio

S.A.E. ALLOY BILLETS AND BARS; OXIDATION AND CORROSION RESISTING STEELS; TOOL AND SPECIAL STEELS; AIRCRAFT QUALITY STEELS; STAINLESS STEELS.



MODEL J-5

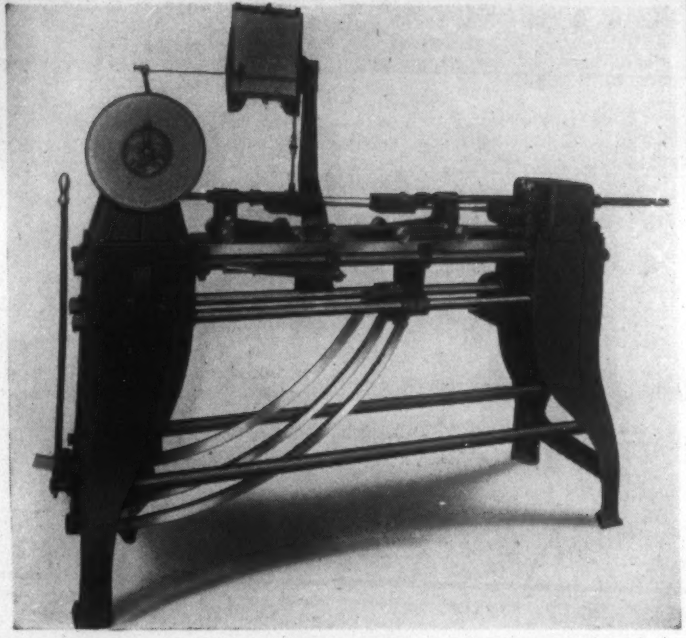
HORIZONTAL
and
VERTICAL

SCOTT TESTERS

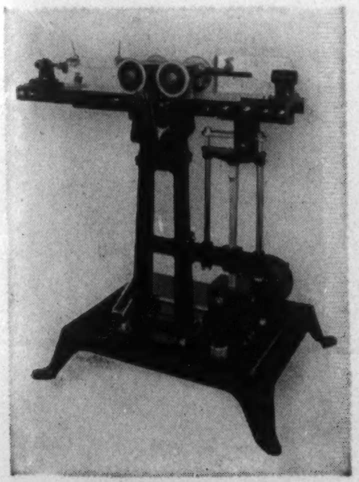
WIRE TESTING MACHINES

Standard for the tire wire industry. Model J-5 above, has cylindrical type recorder which magnifies stress-strain curve in ratios as high as 20 to 1. Clearly shows elastic limit, yield point, ultimate elongation and tensile strength. Capacities, 0-250 to 0-500 lbs. or 0-500 to 0-1000 lbs.

Model Q-4 (right) is of heavier construction to adapt it for tests up to 2000 lbs. Like Model J-5, it measures load by the weighted pendulum principle, and strains specimen with positive gear drive. Can be furnished with cylindrical type recorder.



MODEL Q-4



MODEL 1-P-4

50 GRAMS TO ONE TON

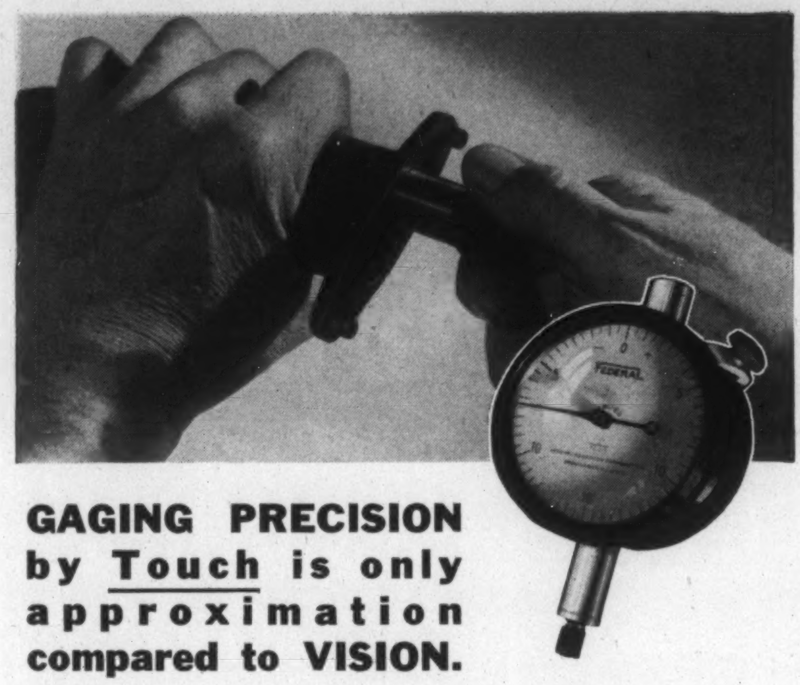
Scott Testers offer the wire industry a range from ONE TON TO AS LOW AS 50 GR. for fine wire testing. Outstanding advantage of Scott Testers is the feature of defining the yield point by drawing the stress strain curve and showing ultimate elongation, tensile strength, and degree of hardness, at the same time.

In Model 1-P-4 (left) for fine wire testing up to 50 lbs., the adjustability in sample length on the incline plane machine allows wires of high or low stretch to be tested on a six inch wide chart.

There will be a Scott representative at the ASTM convention in Atlantic City who will be glad to help you solve your testing problems.

SCOTT TESTERS

HENRY L. SCOTT CO.—PROVIDENCE, R. I.



GAGING PRECISION by Touch is only approximation compared to VISION.

The sense of *feeling* or of *touch* as applied to fixed gages when used to determine the accuracy of specified sizes on machine parts, depends upon the sensitivity of the inspector and varies with each individual.

But, a visible indicating hand, moving over widely spaced dial graduations, is something which can be seen with the same degree of accuracy by *anybody*.

This fact is one of the strongest reasons for using Dial Indicators even for comparatively large tolerances. Send for catalog.

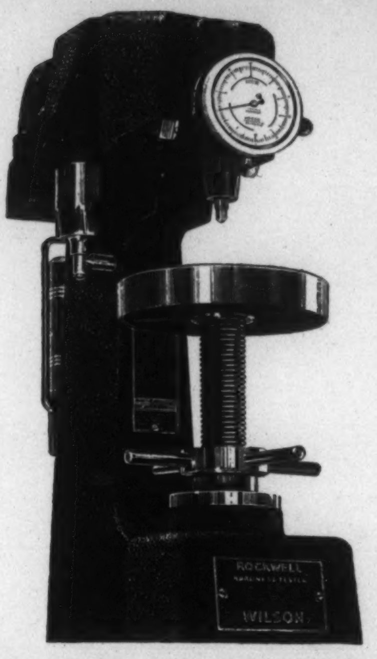
FEDERAL PRODUCTS CORP., PROVIDENCE, R. I.

FEDERAL

PRECISION MEASURING INSTRUMENTS

Chicago • Cleveland • Detroit • Hartford • Muncie
New York • Philadelphia • Pittsburgh • Rochester

"ROCKWELL" HARDNESS TESTER



Its only value to you is its durable precision.

WILSON

MECHANICAL INSTRUMENT CO., INC.
Concord Avenue, N. Y. City

HIGH TEMPERATURES

for testing purposes---

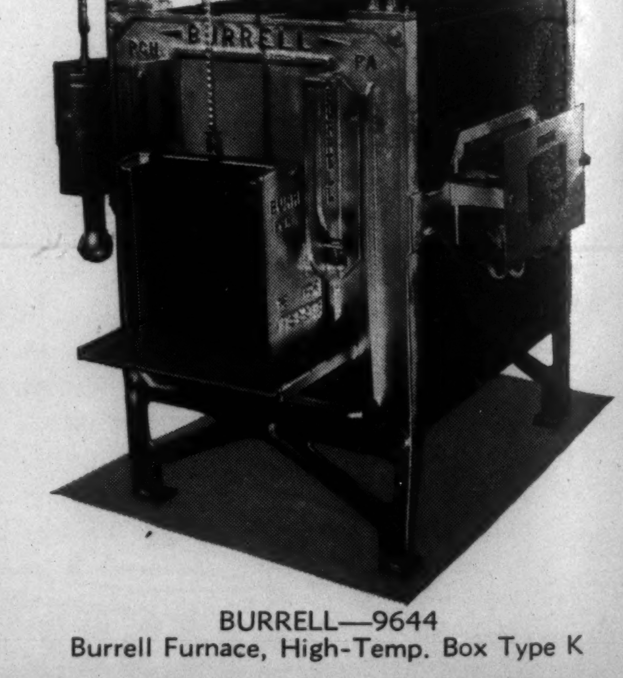
Temperatures up to

2550° F.

The heating chamber measures 4"x4"x13¼" deep. The floor is a removable, refractory plate with moulded sides to prevent spillage from reaching the insulation. Overall outside dimensions of the furnace are 26" wide x 30" high x 24" long. Weight, boxed for shipment, 400 lbs.

The heating elements are designed to give long life but when it is necessary to replace them this operation can be done in five minutes without cooling the furnace.

Other standard models include muffle types —combustion tube types—and pit types. More information on request.



BURRELL—9644
Burrell Furnace, High-Temp. Box Type K

BURRELL SERVICE

Engineering Service is available to those requiring special High Temperature Furnaces not found among the many standard models — please ask us to help solve your problem. - - - - - - - - - - -

BURRELL TECHNICAL SUPPLY COMPANY
1936-42 FIFTH AVENUE « « « « « « « « « « « « « PITTSBURGH, PA. U.S.A.

(Continued from page A12)

"Strength Features of the Tension Test," by F. B. Seely, University of Illinois.

"Limited Significance of Ductility Features of the Tension Test," by H. W. Gillett, Battelle Memorial Institute.

Afternoon

STEEL, FERROALLOYS, METALLOGRAPHY

Report of committee A-1 on steel.

Report of committee A-6 on magnetic properties.

Report of committee A-10 on iron-chromium, iron-chromium-nickel, and related alloys.

Report of sectional committee on standardization of dimensions and materials of wrought iron and wrought steel pipe and tubing.

Report of committee E-4 on metallography.

MARBURG LECTURE

"Portland Cement — Theories (Proved and Otherwise) and Specifications," by P. H. Bates, chief, clay and silicate products division, National Bureau of Standards.

Award of Charles B. Dudley medal.

Evening

CORROSION, IRON

Report of committee A-5 on corrosion of iron and steel.

"Atmospheric Durability of Steels Containing Nickel and Copper," by N. B. Pilling and W. A. Wesley, International Nickel Co., Inc.

Report of committee B-3 on corrosion of nonferrous metals and alloys.

"Influence of Cathode Area and Circuit Resistance in Galvanic Corrosion," by W. A. Wesley, International Nickel Co., Inc.

"Some Observations of the Potentials of Metals and Alloys in Sea Water," by F. L. LaQue and G. L. Cox, International Nickel Co., Inc.

Report of joint committee on exposure tests of plating on nonferrous metals.

Report of committee A-3 on cast iron.

Report of sectional committee A-21 on specifications for cast-iron pipe and fittings.

"Mechanical Properties of Gray Cast Iron," by Jasper O. Draffin, W. L. Collins and C. H. Casberg, University of Illinois.

Report of committee A-7 on malleable iron castings.

"Properties of Commercial Pearlitic Malleable Irons," by C. H. Lorig, Battelle Memorial Institute.

(Continued on page A17)

Z-METAL

Z-Metal is a ductile alloy cast iron the mechanical properties of which, as the result of special heat treatment, are similar to those of certain worked steels. Broad ranges and various combinations of values for strength, hardness and ductility, together with high impact strength and freedom from porosity, are available. Z-Metal's superlative properties are closely related to its characteristic structure—hard spheroids in a tough, ductile ferritic matrix.

★

Z METALS

REG. U. S. PAT. OFF.

★

Heat treating furnaces for the production of Z-Metal are manufactured, under license, by Westinghouse Electric & Mfg. Co.

Companies Licensed to Manufacture Z-Metal

Acme Steel & Malleable Iron Works
Buffalo, N. Y.

Arcade Malleable Iron Company
Worcester, Mass.

Chain Belt Company
Milwaukee, Wisconsin

Chicago Railway Equipment Company
Chicago, Illinois

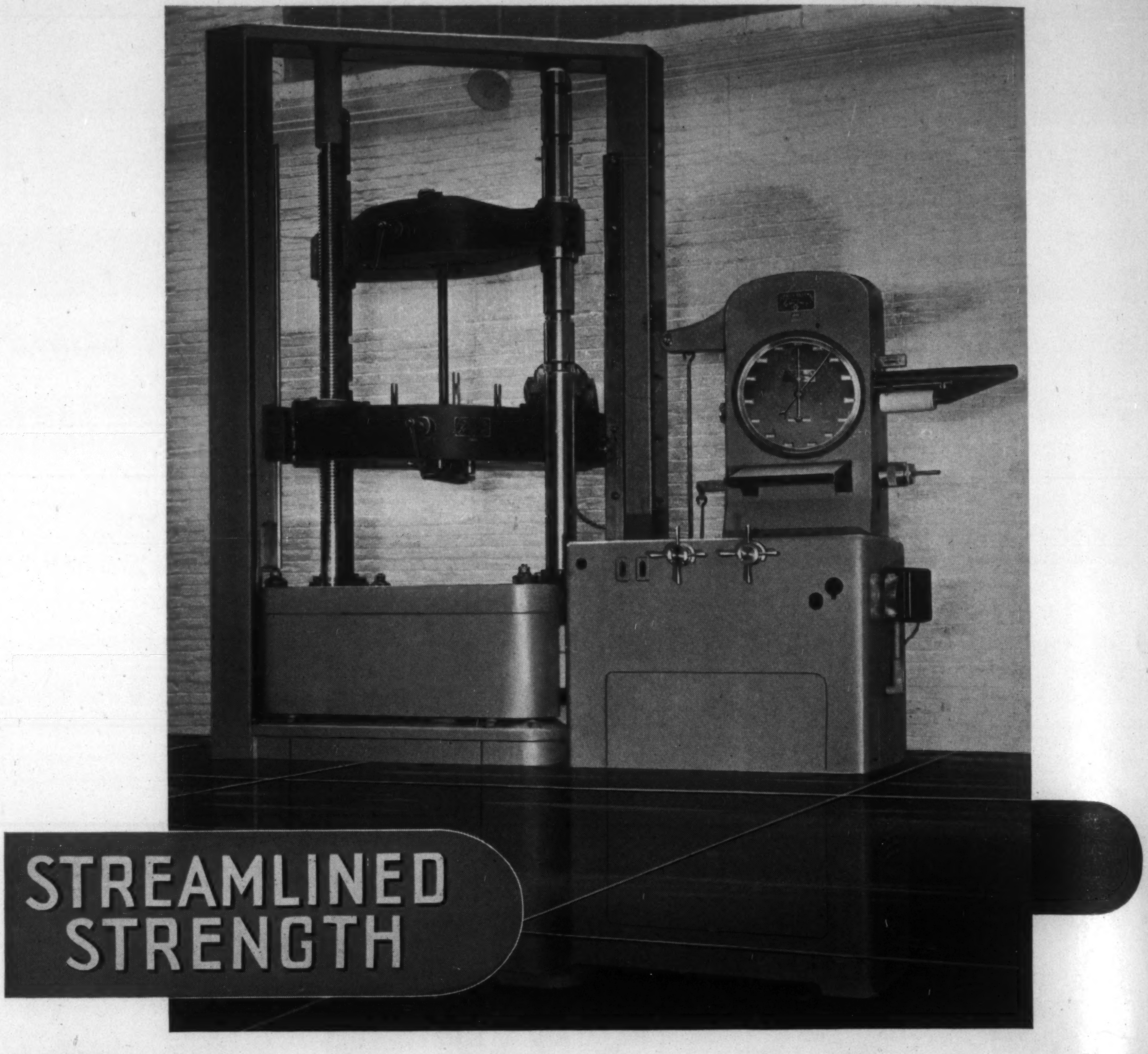
Eastern Malleable Iron Company
Naugatuck, Conn.

Erie Malleable Iron Company
Erie, Pa.

Gunite Foundries Corporation
Rockford, Illinois

FERROUS METALS CORPORATION

444 Madison Ave. • New York, N. Y.



300,000 lb. Universal Hydraulic Testing Machine *by* OLSEN

Modern Olsen equipment is designed by men who know their *applications* as well as the best features of testing machine construction. You are always certain of dependable, accurate, and pleasing appearing equipment, whether your requirements call for a simple dial-type testing machine or the more elaborate equipment with automatic recorder. Just as modern tools frequently show the way to new operating savings, Olsen Testing Machines will modernize your Metallurgical Laboratory. Why not *Streamline* your laboratory with equipment that has proven standard through the years?—Literature and complete information are available on request.

TINIUS OLSEN TESTING MACHINE COMPANY
1202 BUTTONWOOD STREET, PHILADELPHIA, PA.

Tentative Technical Program of A.S.T.M. Convention

(Continued from page A15)

"Stress-Strain Relations for Malleable Cast Iron in Tension with Special Attention to Yield Point Determination," by R. D. Landon, Southern Methodist University.

THURSDAY, June 27
Morning

FATIGUE, CORROSION-FATIGUE

Report of research committee on fatigue of metals.

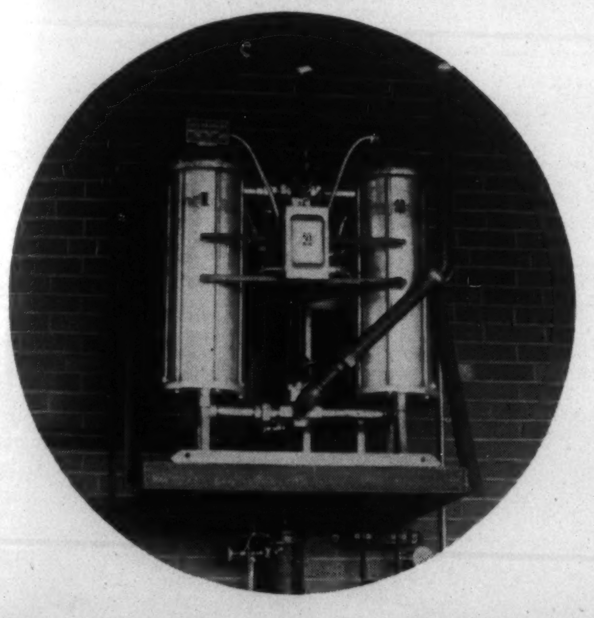
"Fatigue of Porous Metals," by Claus G. Goetzel, Electro Metal Corp., and Richard P. Seelig, Powder Metallurgy Inc.

"Fatigue of 2-Inch Diameter Axles with Surfaces, Metal Coated and Flame Hardened," by O. J. Horger and T. V. Buckwalter, Timken Roller Bearing Co.

"Fatigue Tests on Zinc-Coated Steel Wire," by D. G. Watt, Hydro-Electric Power Commission of Ontario.

"A Pulsating Tension-Fatigue Machine for Small Diameter Wire," by John N. Kenyon, Columbia University.

(Continued on page A18)



LECTRODRYER

REG. U. S. PAT. OFF.

LECTRODRYERS are widely used for complete and thorough drying of annealing and heat treating atmospheres. In sintering furnaces atmospheres dried by the LECTRODRYER protect the heating elements from corrosion. Other uses of LECTRODRYERS are described in bulletin BD. Write for your copy.

PITTSBURGH LECTRODRYER CORPORATION

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Tentative Technical Program of A.S.T.M. Convention

(*Continued from page A17*)

"Effect of Protective Coatings on Corrosion-Fatigue Strength of Steel," by Thomas J. Dolan and Hugh H. Benninger, University of Illinois.

"A Corrosion-Fatigue Test to Determine the Protective Qualities of Metallic Platings," by John N. Kenyon, Columbia University.

SYMPOSIUM ON SPECTROGRAPHIC ANALYSIS

"Variables Versus Constants in Emission Spectrography."

"Accuracy Requirements Versus Reproducibility Possibilities."

Afternoon

SYMPOSIUM ON SPECTROGRAPHIC ANALYSIS

"Interpretation of Results."

EFFECT OF TEMPERATURE, CREEP

Report of joint research committee on effect of temperature on the properties of metals.

"High-Speed Tension Tests at Elevated Temperatures," by M. Manjoine and A. Nadai, Westinghouse Electric & Mfg. Co.

"Creep of 17 Low-Alloy Steels at 1000 Deg. F.," by R. F. Miller, W. G. Benz, United States Steel Corp., and W. E. Unverzagt, National Tube Co.

"Some Effects of Composition and Heat Treatment on High-Temperature Rupture Properties of Ferrous Alloys," by R. H. Thielemann, General Electric Co.

"Creep Recovery at Elevated Temperatures," by P. G. McVetty, Westinghouse Electric & Mfg. Co.

"High Temperature Rupture and Creep Tests," by Ernest L. Robinson, General Electric Co.

FRIDAY, June 28

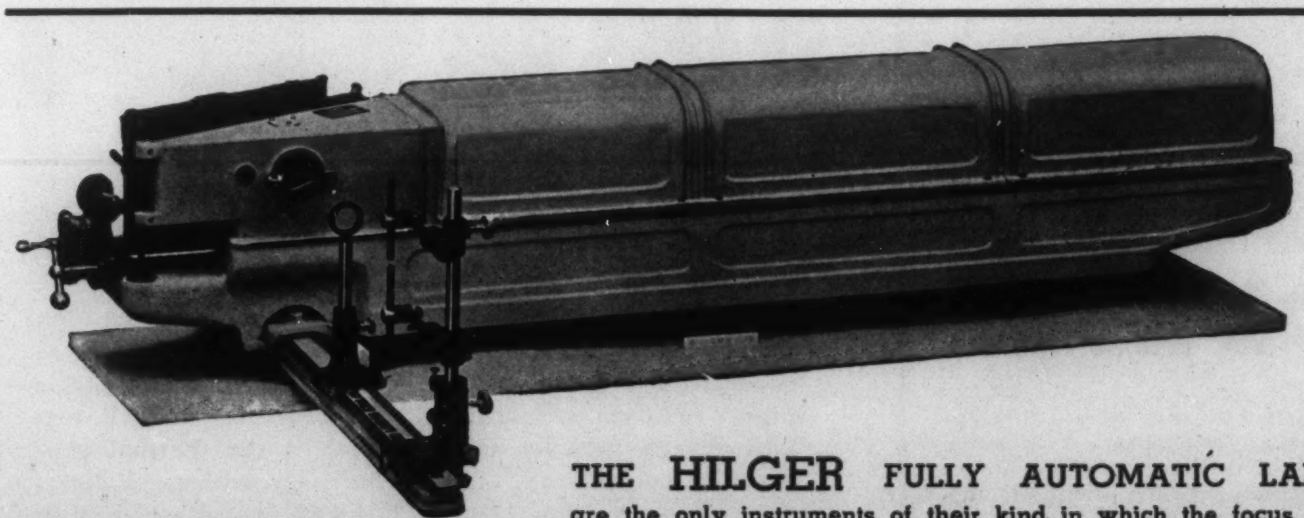
Morning

FUELS

Report of committee D-3 on gaseous fuels.

Report of committee D-5 on coal and coke.

(Continued on page A20)



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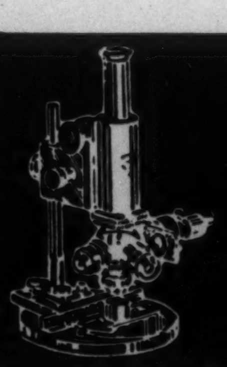

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Tentative Technical Program of A.S.T.M. Convention

(*Continued from page A18*)

NONFERROUS METALS

Report of committee B-5 on copper and copper alloys, cast and wrought.

"Proportional Limit Tests on Copper Alloys," by Cyril S. Smith, American Brass Co.

Report of committee B-2 on nonferrous metals and alloys.

"Internal Hydraulic Bursting Tests of Lead Cable Sheathing," by Howard S. Phelps, Albert M. Gates and Frank Kahn, Philadelphia Electric Co.

"Bursting Tests and Tension Tests for Lead Cable Sheathing," by H. F. Moore, C. W. Dollins and W. J. Craig, University of Illinois.

"Testing of Lead Cable Coverings," by W. H. Bassett Jr. and C. J. Snyder, Anaconda Wire & Cable Co.

Afternoon

NONFERROUS METALS

Report of committee B-6 on die-cast metals and alloys.

Report of committee B-7 on light metals and alloys, cast and wrought.

(Continued on page A22)

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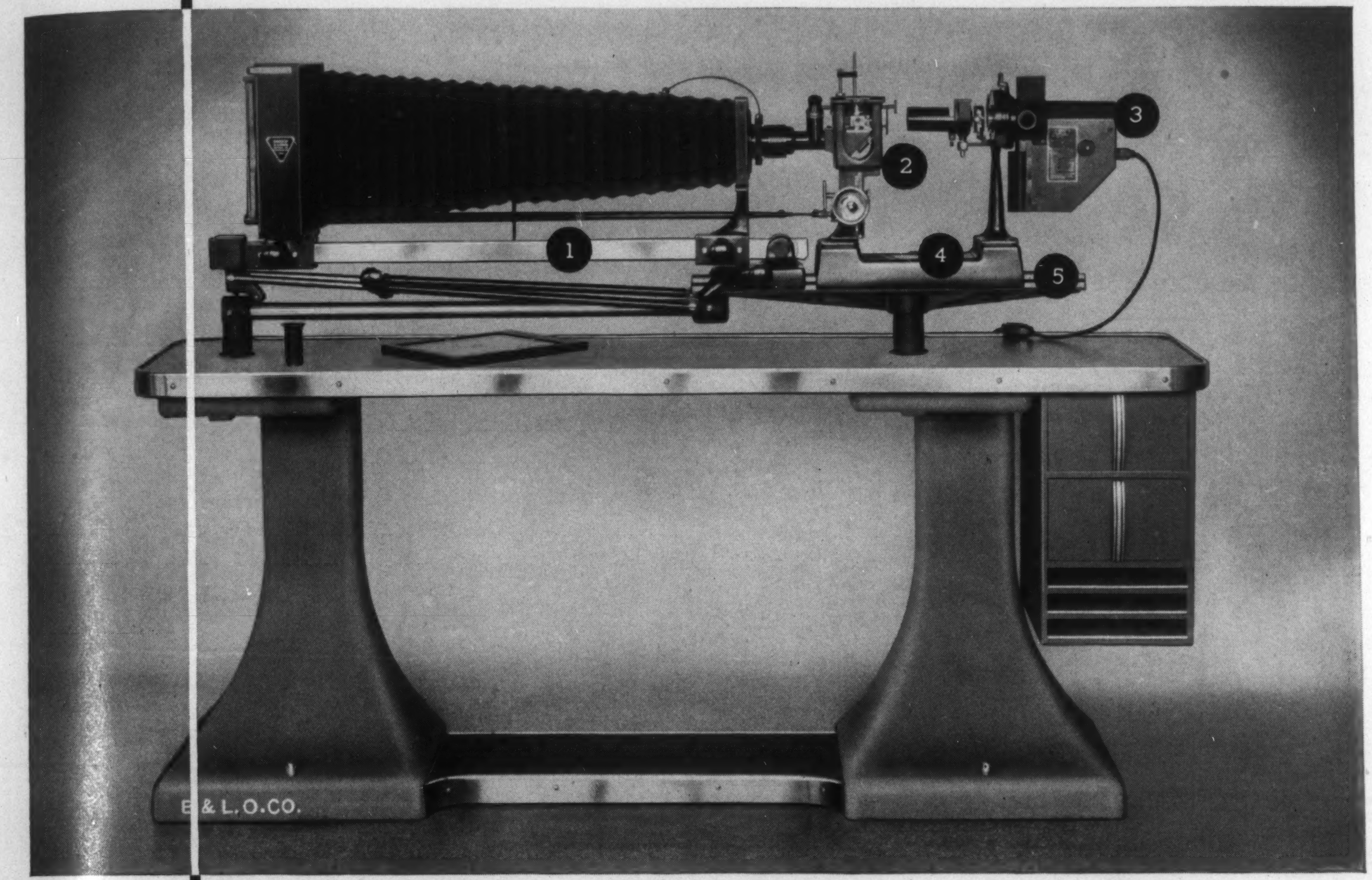

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Tentative Technical Program of A.S.T.M. Convention

(*Continued from page A20*)

"*Anodic Coatings Seen Through the Microscope*," by F. Keller, Aluminum Co. of America.

"*Thickness of Anodic Coatings on Aluminum*," by Junius D. Edwards, Aluminum Co. of America.

"*Abrasion Resistance of Anodically Oxidized Coatings on Aluminum*," by H. G. Arlt, Bell Telephone Laboratories Inc.

"*Electrical Breakdown of Anodically Oxidized Coatings on Aluminum: A Means of Checking Thickness of Anodized Finishes*," by K. G. Compton and A. Mendizza, Bell Telephone Laboratories Inc.

Report of committee B-1 on copper and copper-alloy wires for electrical conductors.

Report of committee B-4 on electrical-heating, electrical-resistance and electric furnace alloys.

"*Creep of Aluminum Subjected to Bending at Normal Temperatures*," by Joseph Marin and L. E. Zwissler, Armour Institute of Technology.

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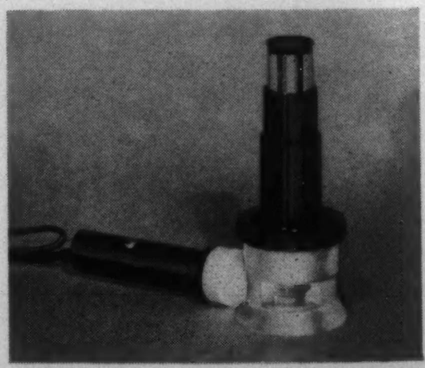

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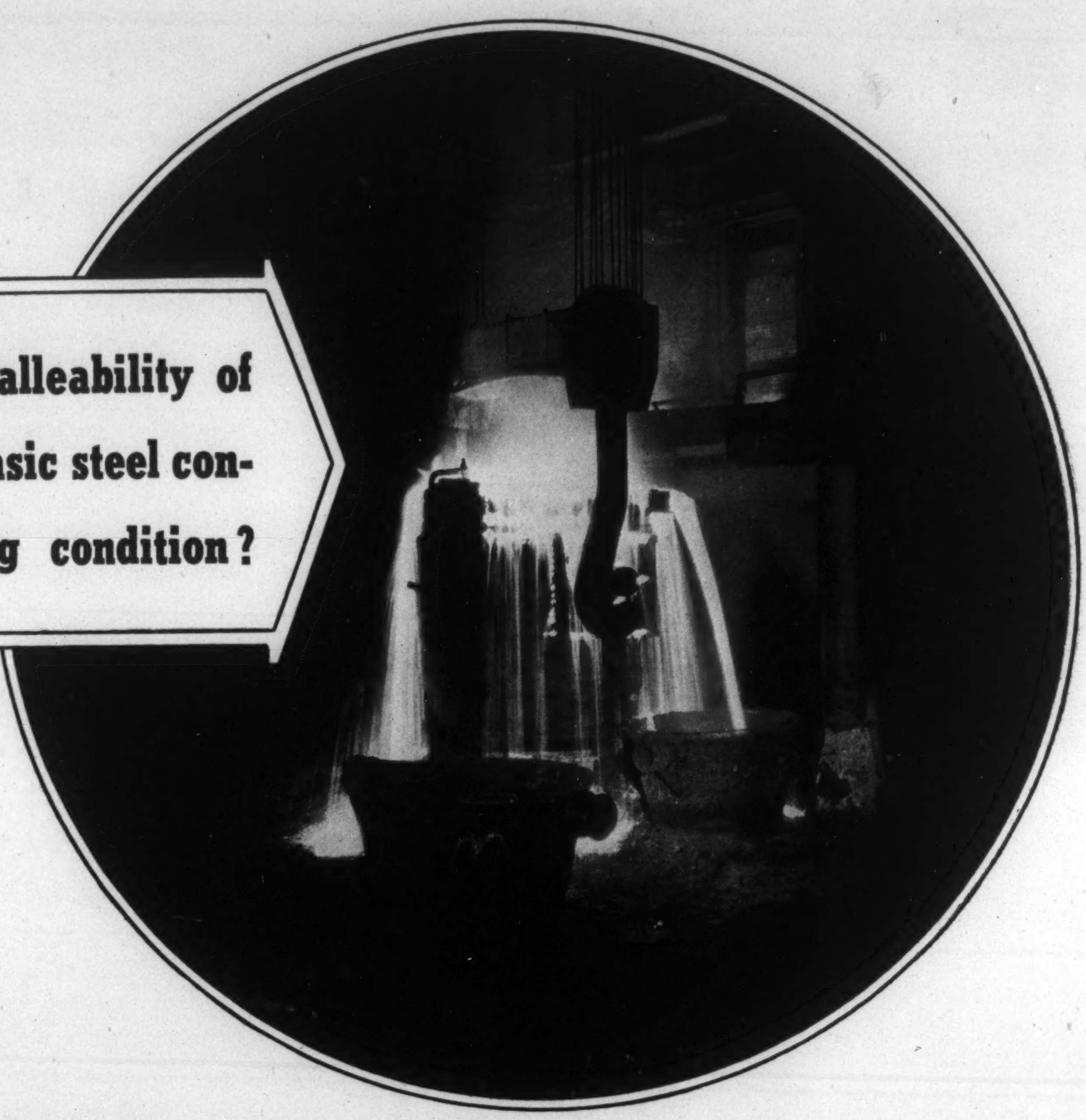

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With the G-E XRD Camera it is possible to identify the crystalline forms present in each slag. By comparing the effects of one slag with those of another in the open-hearth process, a mill will be able to correlate the diffraction analysis with the efficiency of any given slag. From this correlation it is possible to establish a control that will insure profitable operation and complete customer satisfaction.

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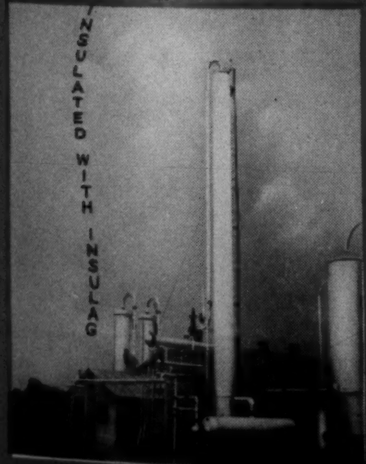

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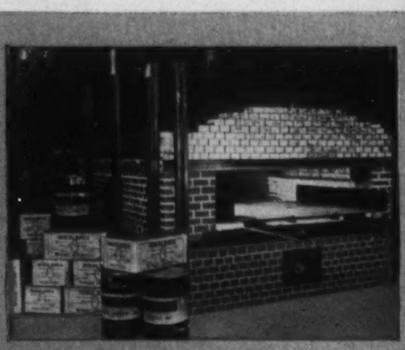

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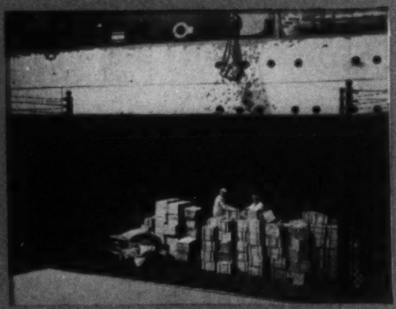
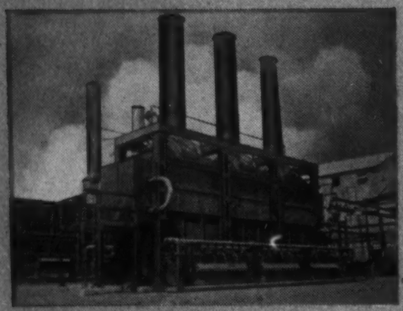


No. 6—One of Fleet with Boiler Settings of Quigley Fire Brick, Laid in Q-CHROME, Q-CHROMASTIC Wash Coat, and Backed with INSULBRIX.



No. 10—Oil Refinery Still—One of Many Quigley Panel-Type Construction Installations with INSULAG and INSULCRETE Removable Panels.

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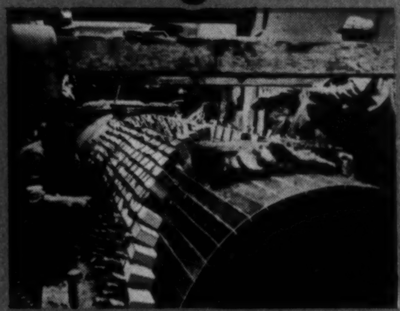

No. 7—City Sewer System—Brickwork of Mains and Manholes Bonded with QUIGLEY ACID-PROOF CEMENT.

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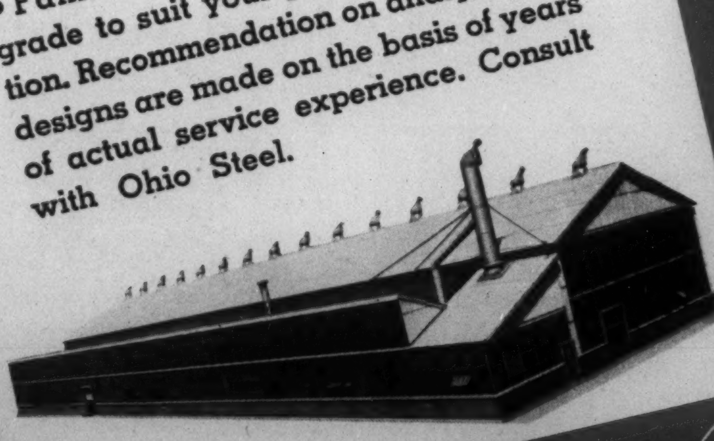

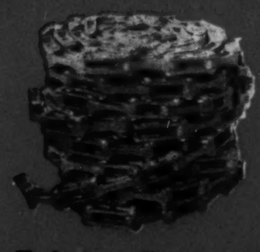

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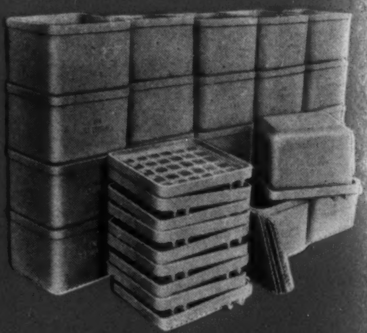

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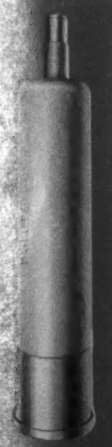

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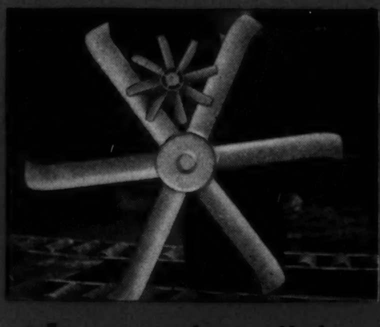

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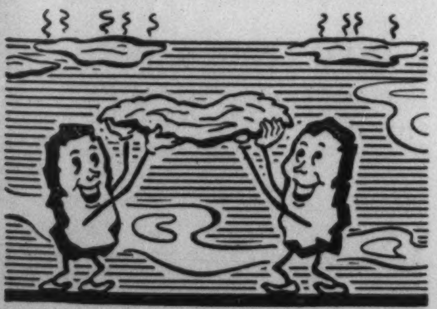

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1. FERROUS METALS

Die Steel

Jessop Steel Company's 3C—a high-carbon, high-chromium tool steel—is said to offer improved machinability and superior die service. Working, heat treatment and applications are described in a 12-page booklet. (1-77)

New High-Strength Steel

This little book gives facts and figures on DYN-EL, a new high strength, flat rolled steel claimed to have unusual resistance to fatigue, impact and corrosion. Complete fabricating and design properties and table of sizes and weights are included. Alan Wood Steel Co. (1-1)

Fine Small Tubing

Superior Tube Co.'s handsome new 12-page booklet reviews the company's facilities and gives some very interesting information on various applications of fine small tubing. (1-47)

Moly High-Speed Steels

Firth-Sterling Steel Co. offers a bulletin on Mo-Chip high-speed steel, a new steel for taps said to offer an unusual combination of required hardness and extraordinary toughness. (1-65)

New High-Strength Steel

Complete mechanical property data on a new low-alloy, high strength and ductile steel, are given for strip, plate and bars in a folder of Great Lakes Steel Co. (1-2)

Nickel-Clad Plate

Bulletin T-4 (Revised, April 1939) contains 16 pages of useful and interesting engineering information on methods for fabricating and on properties and applications of nickel-clad steel plate. Lukens Steel Co. (1-66)

Stainless Machinability Chart

Practical operating data for machining stainless steels are available at a glance through the use of Rustless Iron & Steel Corporation's machinability chart for stainless steels. (1-67)

Free-Machining Open Hearth Steel

LEDLOY, the new lead-bearing, open-hearth, free-cutting steel is described as combining the good qualities of open-hearth steel with the economy of easy machinability. Physical properties of the steel are said to be unaffected by the submicroscopically dispersed lead, although machinability is improved 30-60%. Inland Steel Co. (1-9)

Nitriding Steels

The Nitralloy Corp. has just issued a 29-page engineering booklet (prepared by Dr Homerberg) that covers in complete detail the whole field of nitriding—suitable steels, condition of steel, the nitriding process, applications in industry, published literature, etc. (1-33)

2. NON-FERROUS METALS

New Die Matrix Materials

The Cerromatrix Manual is a handsome 36-page booklet containing interesting descriptions and many illustrations of the properties and applications of Cerromatrix, a low-pressure melting alloy of bismuth, lead, tin and antimony. Cerro de Pasco Copper Corp. (2-78)

Special Bronze in New Machine

Engineering Data Sheet No. 76 of Ampco Metal, Inc., describes in interesting fashion the various applications of Ampco Metal grades 18 and 20 in the "world's fastest stapling machine," built by International Stapling Machine Co. (2-79)

Nickel-Chromium Alloy Products

A 4-page bulletin of Alloy Metal Wire Co., Inc., describes the mechanical properties, service performance and some of the current applications of Inconel wire rod and strip for high temperature or corrosion-resisting applications. (2-81)

Tungsten, Molybdenum and Alloys

The versatile experience and varied line of products of Callite Tungsten Co. are featured in a bulletin describing special refractory Callite alloys, carbides and other unusual metallurgical products. (2-49)

Copper, Brass and Bronze Weights and Data

A comprehensive and detailed 32-page catalog of Revere Copper & Brass Co. presents tabular weight data for various sizes and thicknesses of copper, brass and bronze products. Distribution is limited to engineers, draftsmen, estimators and designers. (2-82)

Silicon Brass Casting Alloys

Ajax Tombasil alloys for the production of silicon brass castings are the subject of an interesting illustrated 8-page booklet of Ajax Metal Co. Typical sand castings, chill castings and die castings of these alloys are discussed and manufacturing practice described. (2-83)

Beryllium-Copper Alloys

The first of a series of engineering data sheets to be issued by Beryllium Corp. of America contains 7 pages of useful information on the composition, available forms and tempers, best treatment, physical properties and uses of Berylco No. 25, a copper-beryllium alloy containing small amounts of cobalt. (2-80)

Illium in Rolled Form

Bulletin 103 of Burgess-Parr Co. gives engineering properties and applications of a new product—corrosion-resistant Illium in rolled form—now available. (2-46)

Phosphor Bronze

The Phosphor Bronze Smelting Co. has issued a 44-page catalog of Elephant Brand phosphor bronze wire, sheets, rods and tubes, and other alloy products. (2-72)

Dowmetal Data Book

A new edition, containing especially significant accomplishments in the sections Available Forms and Shop Practice has been published by Dow Chemical Co., Dowmetal Div. (2-18)

Forgeable Bearing Metal

The properties and applications of 600 Metal, described as a true bearing alloy that can advantageously replace cast bronze bearing metal and which can be forged or drawn to a variety of sizes and shapes, are discussed in literature of Ferrous Metals Corp. (2-77)

Engineering Properties of Nickel

Bulletin T-15 of the International Nickel Co. contains 18 pages of complete and highly useful data on the properties of nickel, with illustrations of many applications. A separate section devoted to certain special nickel alloys is included. (2-32)

Metal Hydrides

Reprints of a series of articles by P. P. Alexander on "The Hydride Process," in METALS AND ALLOYS, are available. History, production and the uses of metal hydrides are discussed. Metal Hydrides, Inc. (2-6)

3. METAL FORMS • METAL PARTS • ENGINEERING DESIGN

Die Castings

Madison-Kipp Corp., in a new 32-page catalog, describe their industrial die casting service, Kippcaster die casting machines, and discuss typical die designs that have been used by this company in their manufacture of die castings. (3-52)

X-ray'd Castings

Composition, physical properties and general fields of service of 7 types of X-ray inspected Thermalloy are given, in Bulletin 102. Electro Alloys Co. (3-40)

Drop Forgings

Seven important advantages claimed to result from the use of forgings in the construction of many types of mechanical parts and equipment are cited, and a large number of individual examples of various products and designs for drop forgings are described and illustrated in an attractive 8-page folder of Drop Forging Assn. (3-51)

Malleable Iron Castings

"Malleable Iron," a section of the A.F.A.'s cast metals handbook, offers 50 pages of the latest, most authoritative data on the properties and utility of malleable iron castings. Malleable Founders' Society. (3-50)

Heat Resisting Alloy

The physical properties at room and at elevated temperatures, and some typical applications of Pyrasteel, a Cr-Ni-Si-Fe alloy, are given in an 8-page bulletin. Chicago Steel Foundry Co. (3-19)

Pressure Vessel Fittings

Descriptive and price information on Lenape Hydraulic Pressing & Forging Company's seamless welding necks and other fittings for pressure vessels and kindred fabricated structures is given in a comprehensive catalog. (3-41)

New Engineering Material

Neoprene, a product of the Rubber Chemicals Div. of E. I. du Pont de Nemours & Co., Inc., is finding wide use in engineering design in places where metals, plastics, fabrics and other materials, throughout a variety of industries, were once used, according to information in the current issue of this company's Neoprene Notebook. (3-39)

Silver-Stainless Steel Castings

A folder describing the nature, properties and special advantages of the silver-bearing "18 and 8" stainless steel castings—claimed to offer greater resistance to pitting corrosion and better machinability—is available from Lebanon Steel Foundry. (3-31)

Electro-Polished Stainless Steel Castings

Lustracast, a new electrolytic process that cleans, polishes and passivates stainless steel castings is discussed, and stainless steel castings so finished are described in a handy 4-page booklet of Cooper Alloy Foundry Co. (3-35)

Thermostatic Bi-Metal

Complete information on Dole thermostatic bi-metal, in the form of spirals, coils, strips, sheets, prefabricated parts or complete assemblies is offered by Dole Valve Co. (3-44)

Alloys for Heat and Corrosion Resistance

A well-illustrated interesting 8-page bulletin of Duraloy Co. gives useful engineering data and typical applications for Duraloy chromium-nickel, chromium-iron and nickel-chromium heat and corrosion resistant alloys. (3-28)

Alloy Heat Exchangers

Illustrated 8-page bulletin (No. 1601-A) describes the construction and use of heat exchangers for corrosive liquids made of Duriron, Durimet, Durco stainless or Alcumite. Useful thermal operating data are included. Duriron Co. (3-6)

Composite Silver Rivets

Users of solid silver contacts for electrical purposes are offered a new construction that provides greater economy without loss of efficiency, according to a folder of H. A. Wilson Co. (3-47)

Metal for Pressure Castings

The applications and serviceability of Meehanite metal for pressure castings such as pumps, valves, steam chests, mixers, engine parts, etc., are discussed in an interesting illustrated 12-page booklet of Meehanite Metal Corp. (3-32)

Electroformed Screens

Samples of Lektromesh, the new electroformed screen material that is functionally intermediate between woven wire and perforated metal, will be sent along with descriptive information from C. O. Jelliff Corp. (3-45)

Self-Lubricating Bearings

An attractive, interesting and highly useful 16-page catalog of R. W. Rhoades Metaline Co., Inc. discusses Metaline "oilless" bronze bearings, and includes engineering data and illustrations of many applications. (3-46)

Heat Resisting Alloy Castings

Data on applications are given in a bulletin dealing with installations where strength at high temperatures must be provided. Ohio Steel Foundry Co. (3-3)

4. MELTING • REFINING • CASTING

(See also Section 6)

Vacuum and Pressure Melting

An interesting folder of Ajax Electrothermic Corp. describes and illustrates a few applications of Ajax-Northrup furnaces used in vacuum melting and casting and in melting in a gas atmosphere. (4-34)

Rocking Electric Furnaces

Castings or ingots of ferrous or non-ferrous metals can be advantageously melted in Detroit rocking electric furnaces, according to a 24-page bulletin that discusses applications and gives furnace specifications. Detroit Electric Furnace Div., Kuhlman Electric Co. (4-40)

Graphite Crucibles

Graphite crucibles, funnels, ladle liners, dippers and other melting auxiliaries manufactured by American Crucible Co. are described in a detailed and well-illustrated 24-page catalog. (4-37)

Electric Furnace Electrodes

An interesting and technically useful 8-page booklet of Great Lakes Carbon Corp. comprises a practical presentation on the origin, manufacture and use of electrodes made of carbon and graphite. (4-38)

Ferrocarbo

This material, containing both silicon and carbon combined in the form of silicon carbide, acts as a graphitizer or softener when added to cast iron. Carborundum Co., Refractories Div. (4-11)

Crucible Furnaces

Descriptive details and complete specifications for Walker-York coke-fired crucible melting units for the foundry, in capacities from 80 lbs. to 1,000 lbs., are given in a highly useful 6-page bulletin of Crucible Furnace Co., Inc. (4-35)

Cutting Crucible Costs

The Crucible Manufacturers' Assn. has issued a useful and interesting 16-page booklet on the storing, handling and use of melting crucibles. Useful alloy data are also included. (4-36)

Magnetic Separators

The Stearns "High-Duty Type L" magnetic separators, especially designed for removing iron and steel admixtures from secondary metals like brass and aluminum, are the subject of a new bulletin of Stearns Magnetic Mfg. Co. (4-39)

Electric Melting Furnaces

Copiously illustrated 18-page bulletin discusses applications of electric melting furnaces in general and types, salient features, typical installations and practical advantages of Heroult furnaces in particular. American Bridge Co., United States Steel Corp. Subsidiary. (4-13)

Core Binder

Two publications of Hercules Powder Co. —the first a description of Truline binder and its applicability, with comparative data for other binders, and the second a brochure outlining "What Hercules Is Doing for the Foundry"—are offered. (4-32)

Foundry Zircon Flour and Sand

Tam foundry zircon flour and sand, and their applications in modern foundry practice, are discussed in an interesting 4-page bulletin that gives mixtures and their preparation as well as many data on the properties of these materials. Titanium Alloy Mfg. Co. (4-19)

5. HEAT TREATMENT • HEATING

(See also Section 6)

Gas Atmosphere Producer

Sargeant & Wilbur's gas converter produces a low-cost reducing atmosphere suitable for bright-annealing, brazing or soldering many non-ferrous alloys and steels, according to information from this company. (5-108)

Nitrogen for Furnace Atmospheres

A new nitrogen generator, stated to produce this non-explosive, non-toxic, chemically inert gas at low cost is described in this 4-page bulletin. Mahr Mfg. Co. (5-12)

CONTINUED NEXT PAGE

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5/40

Proportioning Oil Burner

Accurate combustion, closer temperature control and greater fuel economy are claimed for the Hauck proportioning oil burner, in a 4-page bulletin that gives specifications, design and operating data. Hauck Mfg. Co. (5-104)

Safe Combustion

A readable, well-illustrated 16-page bulletin of Wheelco Instruments Co. provides complete information on the Wheelco Flame-otrol, Model 1101A—a combustion safeguard applicable to the protection of gas burners, oil burners, powdered coal burners and combinations of these fuels. (5-107)

Heat Treating Furnaces

An unusually comprehensive, well-illustrated 24-page broadside of Leeds & Northrup Co. gives practical operating and engineering data and a wealth of descriptive material on L & N furnaces for carburizing, tempering, hardening and nitriding. (5-106)

Selective Carburizing Compounds

Sel-Car, used for protecting steel against decarburization during heat treatment and preventing carbon penetration in localized areas during carburizing, is discussed and methods of application described in a 6-page bulletin of National Copper Paint Corp. (5-105)

Blower for Oil Burning

Reliable and quiet operation, constant pressure over the entire volume range, power savings, and a complete range of sizes are claimed for the new Type "G" Motorblower for oil-fired furnaces, in an 8-page bulletin of Ingersoll-Rand Co. (5-102)

Liquid Bath Electric Furnaces

An illustrated 4-page bulletin of Bellis Heat Treating Co. reviews the construction, operation and application of Bellislavite electrode-type furnaces for annealing, tempering, case-hardening, hardening, and heating for forging. (5-87)

Electric Forging Heaters

Berwick heaters employ the direct electric resistance method to heat the metal, and feature temperature control by photocell. Advantages claimed are speed, uniformity, absence of distortion, and economy. American Car and Foundry Co. (5-23)

Blowerless Furnaces

Baker small gas-fired furnaces that operate at 1850 to 2300 deg. F. without blower or compressed air are discussed in an illustrated 8-page booklet of Baker & Co. Applications in tool-room, dental laboratory, for treating high-speed steel, for bright annealing and for fluxless brazing are described. (5-59)

Combustion Control System

The Isley system of regenerative furnace combustion control and its application to soaking pits, slab, bloom and billet heating furnaces, and forging furnaces, are discussed in an illustrated 8-page bulletin. Morgan Construction Co. (5-89)

Control of Furnace Atmosphere

Two bulletins devoted to a description of "Certain Curtain Control of Atmosphere" and to furnaces for pre-heating and hardening high-speed steel have been issued by C. I. Hayes, Inc. (5-33)

Carburizing Unit

The Hevi-Duty Carburizer is an electric furnace unit using the Carbonol (carefully blended gas-producing oil) process, which is claimed to provide uniform case depth, improvement in quality, cleanliness and other advantages. Hevi Duty Electric Co. (5-2)

Electric Pot Furnaces

Cylindrical electric pot furnaces (Model P), for lead, salt and cyanide bath treatment are discussed in a 2-page bulletin of American Electric Furnace Co. (5-97)

Controlled Atmosphere Equipment

"What to Do About Controlled Annealing Atmospheres" is the title of an 8-page bulletin describing atmosphere producers, gas composition monitors and other heat treating equipment of C. M. Kemp Mfg. Co. (5-91)

Burners for Industrial Furnaces

This illustrated, 4-page folder is devoted to the new Duradiant burner whose outstanding feature is a refractory burner tip. Chamber temperatures from 300 to 2400° F. can be produced. Selas Co. (5-32)

Bright Annealing Furnaces

Furnaces for "wet" or "dry" bright annealing, heat treating, stress relieving, etc., are described in an interesting folder of Charles F. Kenworthy, Inc. (5-43)

Heating Copper and Brass

Replete with operating data, this highly interesting, beautifully illustrated, 4-page bulletin of Surface Combustion offers much information on furnaces for heating and heat treating copper and brass in several sizes and forms. (5-70)

6. REFRACTORIES • INSULATION

Sillimanite Refractories

An illustrated 4-page bulletin of General Refractories Co. gives the properties, applications and handling procedure for GRCO sillimanite brick, cement and plastic material, plus useful engineering data on silica-alumina mixtures. (6-35)

Magnesite Refractory

Basifrit, a quick-setting magnesite refractory for new basic hearths or for repair and general maintenance, is interestingly described in a 4-page booklet of Basic Dolomite, Inc. (6-34)

Super Refractories

Catalog No. 301 of Chas. Taylor Sons Co. is replete with useful data on P. B. Sillimanite refractories for use up to 3300 deg. F. in electric furnace roofs and linings, induction furnaces, crucible furnaces, fuel-fired hearths, piers and linings, burner blocks, etc. (6-16)

Fire Clay Products

Various Goose Lake fire clay products—brick, flour, bond, standard fire clay, and high-silica clay—and Therm-O-Flake high temperature insulation are described in a folder of Illinois Clay Products Co. (6-30)

Insulating Refractory Concrete

This compact 4-page folder is devoted to Insulcrete, a light-weight cellular insulating refractory concrete used for direct exposure to flame and furnace gases up to 2500 deg. F. in fuel-fired or electric furnaces. Properties, uses and methods of applying are given. Quigley Co., Inc. (6-18)

Refractory Ware

Thermal Alumina ware that can be used for working temperatures up to 1950 deg. C. for the fusion of metals, alloys and alkalies under corrosive conditions, is the subject of an illustrated leaflet of Thermal Syndicate Ltd. (6-5)

High Temperature Insulation

An illustrated leaflet is devoted to types and uses of thermal insulation, for all types of heating equipment. Armstrong Cork Co. (6-10)

Refractory Concrete

Refractory concrete made with Lumnite is described in a 24-page illustrated booklet of Atlas Lumnite Cement Co. Interesting and useful information on methods of making refractory concrete for several types of furnaces and various degrees of service is presented. (6-36)

7. WELDING • CUTTING

Stainless Welding Electrodes

Eight pages of illustrated description, with tabular engineering data, on Arcos electrodes for welding stainless steel and also bronze, cast iron, special mild steel and nickel electrodes are contained in a useful bulletin of Arcos Corporation. (7-42)

Stainless Steel Welding Electrodes

A type of Rezistal electrode for every stainless welding job is claimed for the line of extruded flux-coated electrodes described by Crucible Steel Co. of America in a brand new 6-page folder. Names, type numbers, compositions, prices and applicabilities are given. (7-40)

Quick Heat Soldering Iron

A leaflet of Ideal Commutator Dresser Co. describes the new Ideal "quick heat" soldering iron, claimed to provide almost instantaneous heating, light weight and easy handling, improved safety and high efficiency. (7-41)

Resistance Welding Electrodes

Complete 9-page catalog outlining physical properties recommendations and specifications of various alloys for all types of resistance welding electrodes is available from Electroloy Co., Inc. (7-20)

Stainless Electrodes

McKay "Certified" stainless electrodes for arc welding stainless steels are discussed in a new 16-page booklet that gives analyses, applications, operating data, etc. McKay Co. (7-16)

Shielded Arc Welding

The new Lincoln "Shield-Arc" welder with self-indicating dual continuous control is described and applications and operating technique discussed in a new 20-page bulletin of Lincoln Electric Co. Auxiliary electrical supplies are also included. (7-19)

Stainless and Heat Resisting Electrodes

Price list and data book containing descriptions of the company's products and analyses of stainless and heat resisting alloys manufactured by other companies. Maurath, Inc. (7-2)

Heavy-Coated Electrodes

Murex heavy mineral-coated arc welding electrodes are described in this well-illustrated 16-page bulletin. Metallurgical advantages, types of electrodes for various metals and newer steels, and typical Murex-welded jobs are discussed. Metal and Thermit Corp. (7-13)

8. METAL WORKING • HANDLING

Bending Presses

A new catalog of Cleveland Crane & Engineering Co. presents 28 pages of descriptive and illustrative material on Steelweld all-welded bending presses, featuring soundness of construction, ease of operation, superior performance and modern styling. (8-39)

Cutting Oils

Cities Service Oil Co. has published a comprehensive, readable bulletin on the theory and practice of metal cutting lubrication. Types of lubricants and their intelligent application are discussed. (8-19)

Brazed Hard-Alloy-Tipped Tools

Tantung brazed tipped tools for cutting steel offer resistance to wear, impact and heat, with higher heat resistance than high-speed tools and greater strength than ordinary cemented carbides, according to an 8-page folder of Fansteel Metallurgical Corp. (8-37)

Cemented Carbide Tools and Dies

A beautiful 12-page brochure of Carboloy Co., Inc., describes Warner & Swasey Co.'s application of Carboloy tools in machining of 1,500 small-lot jobs, 40% of which were on steel. Working data and many illustrations are included. (8-38)

Grinding Carbide Cutting Tools

A new wall chart, containing instructions for the correct grinding of Kennametal steel-cutting carbide tools, has just been issued by McKenna Metals Co. (8-23)

9. PLATING • FINISHING • RUSTPROOFING

Flame Cleaning Steel

Reprints of two interesting articles that describe the use of Airco equipment for flame-cleaning and flame-dehydrating large steel structures are included in a new 8-page booklet of Air Reduction Sales Co. (9-54)

Corrosion Resisting Paint

In an 8-page folder, Pennsylvania Salt Mfg. Co. describes the nature and applications of Pennpaint, a chlorinated rubber paint claimed to have remarkable resistance to alkalies and acids, and to be applicable to iron, steel, concrete, etc. (9-52)

Electroplate Thickness Testing

A method of rapidly determining the thickness of zinc, cadmium, tin and copper electrodeposits, developed by Hull & Strausser, said to be particularly useful in connection with electrotinning and high-speed copper plating, is described in a new technical service manual of E. I. duPont de Nemours & Co., Electroplating Div. (9-57)

Copper Coating of Steel

Descriptive and procedural details about Cuprodine—a solution for coating copper on steel without current—are given in a 4-page folder of American Chemical Paint Co. Good adherence, brightness and rapid operation are claimed. (9-55)

Filtering Plating Solutions

Hy-Speed plating filters, claimed to give ultra fine filtration in a much smaller unit than conventionally employed, and the special type of filter disks said to make this possible, are described and illustrated in a 4-page bulletin of Alsop Engineering Corp. (9-56)

Black Finish on Steel

Heatbath Corporation has issued a 4-page bulletin on Pentrate, described as a penetrating black finish for steel products applied through chemical treatment in hot solutions. (9-53)

Vapor-Spray-Vapor Detrex Degreaser

This special machine equipped with a monorail conveyor is described in literature from the Detroit Rex Products Co. (9-50)

Pickling Stainless Steel

Ferrisul, a pickling bath especially suited for stainless steel, is described and detailed recommendations for its practical application to the pickling of stainless steel in various forms are given, in literature of Merrimac Div., Monsanto Chemical Co. (9-39)

10. TESTING • INSPECTION • CONTROL

Spectroscope for Shop Use

The application of the Spekker Steeloscope to the rapid estimation of alloying elements in steel, for quick, reliable sorting and checking of steel stock, production lots, purchases and scrap, is described in a useful 15-page booklet of Jarrell-Ash Co. (10-103)

Torsion Impact Machine

The Carpenter torsion impact testing machine, its uses for evaluating metals and interpretation of its results are all discussed in an illustrated 8-page engineering bulletin of Baldwin-Southwark Div. (10-99)

Electric Tubing Inspector

The Sperry electric detector for tubes can be used for locating defects in either magnetic or non-magnetic metals on a rapid production-inspection scale, according to a descriptive 4-page bulletin of Sperry Products, Inc. (10-100)

Furnace Control System

The operating features and applications as well as details of construction and electrical circuit of the Reactrol system of furnace control are given in an interesting 6-page folder of General Electric Co. (10-88)

High Temperature Combustion Furnaces

Single and double tube laboratory furnaces, provided with Globar elements producing temperatures up to 2500° F., are described in a bulletin of Burrell Technical Supply Co. (10-15)

New Illuminated Magnifier

The Pike-o-Scope, an electrically illuminated magnifier said to be useful for all general inspections is described in a leaflet of E. W. Pike & Co. (10-58)

Temperature Controllers

Type 2600 current-input controllers for electrically heated furnaces and ovens, developed to provide greater operating economy and constancy, are described in a 6-page folder of Automatic Temperature Control Co. (10-95)

Metallurgical Laboratory Equipment

Loose-leaf data sheets issued by Harry W. Dietert Co. give specifications, operating descriptions and applications of several laboratory units, such as Globar-tube furnaces, metallographic specimen dryers, carbon determinators, sulphur determinators, sand and refractory dilatometers, and portable pyrometers. (10-50)

Radium for Metal Inspection

The use of radium for the radiographic examination of castings, welds, and other forms of metal to establish their quality is described, with complete data on industrial practice, in a technical pamphlet issued by Radium Chemical Co., Inc. (10-81)

Gas Analysis

Bulletin describing the thermal conductivity method of gas analysis is published by Charles Engelhard, Inc. (10-83)

X-ray Analysis

The "Metalix" crystal analysis unit, its applications to research in the fields of iron and steel and light alloys, and the interpretation of exposures are treated in a series of pamphlets of Philips Metalix Corp. (10-77)

Please Use the Coupon on Page A 29

Wire Tester

A new tensile testing machine for wire, sheet metal and other small-size samples is described in a new bulletin. The machine is claimed to be simple, rugged and unusually accurate; an automatic recorder plots stress vs. strain and permits quick determination of yield points, total elongation, etc. Henry L. Scott Co. (10-23)

Precision Gages

A well-illustrated 64-page catalog contains specifications and operating data on a variety of precision measuring instruments for inspection and control work. The devices are applied to checking dimensions, etc. Federal Products Corp. (10-94)

Instruments and Measuring Equipment

A mimeographed list of products manufactured by the Bristol Co. enumerates dozens of types of instruments, gages and measuring systems and, in addition, classifies them according to property measured. An accompanying folder illustrates and describes several products. (10-84)

Control Instruments

Brown "Air-o-Line" (air-operated) controllers are discussed, and typical installations illustrated in a new bulletin of Brown Instrument Co. (10-17)

Metallurgical Testing Apparatus

The latest edition of *The Metal Analyst*, just out, contains 98 pages of highly useful and attractively presented information on metallographic and metallurgical testing equipment, spectrographic apparatus and optical instruments, and a 1053-reference bibliography on relevant technical publications. Adolph I. Buehler. (10-80)

The X-Ray in Industry

The application of X-ray examination and inspection to castings and welds and of X-ray diffraction to studies of internal changes in metals during cold working, etc. is exhaustively covered in this 35-page catalog, replete with illustrations. General Electric X-Ray Corp. (10-10)

Surface Pyrometers

Illinois Testing Laboratories, Inc., have prepared a 4-page bulletin on the improved Alnor surface pyrometer, known as the Pyrocon, for measuring surface temperatures of metals or other materials, either in motion or fixed. (10-101)

Metallographic Polishing Equipment

The new Jarrett metallographic polishing machine, said to be almost completely automatic, and the Jarrett specimen mounting press are described in literature of Tracy C. Jarrett. (10-65)

11. GENERAL

Air and Gas Conditioning

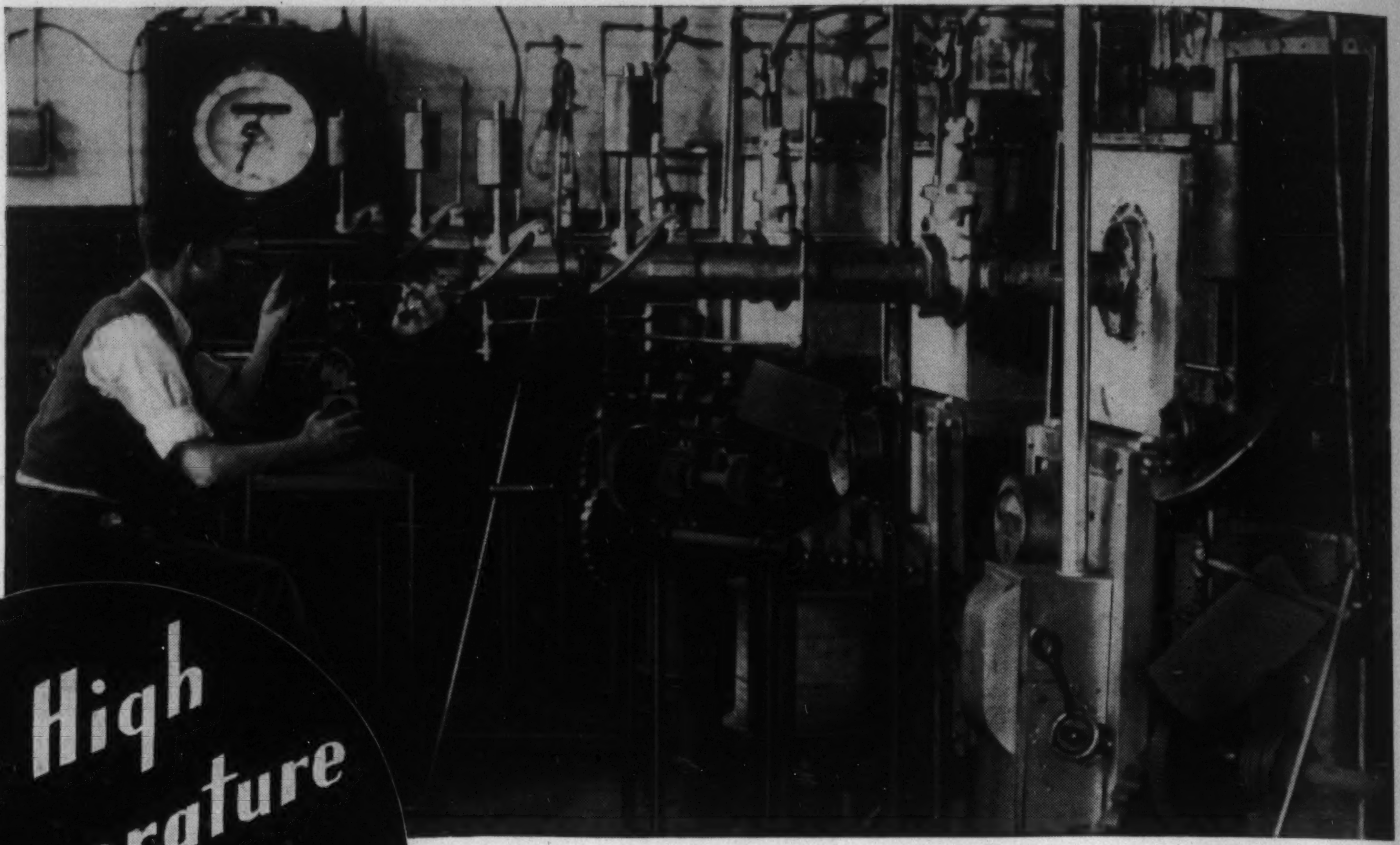
The functioning and applications of Logan Engineering Co.'s Aridifier, used for the centrifugal removal of moisture, dirt, iron and fine scale from compressed air and gases are described in a 4-page bulletin. (11-20)

Industrial Floor Material

Best described as a hard mastic, Permaflex floor resurfacing or patching material offers economy, wear resistance, slip proofing and excellent adhesion, according to a 4-page bulletin of Permaflex Products Co. (11-18)

Dust Control

The economic importance of dust control in metal-working operations is emphasized and several applications of Pangborn collectors are illustrated in an interesting bulletin just issued by Pangborn Corp. (11-12)



For High Temperature Operation...

ALUNDUM TUBES AND CEMENTS

Molybdenum wound furnaces using Alundum Tubes and Alundum Cement are used extensively in the North Chicago plants of Fansteel Metallurgical Corporation and Vascoloy-Ramet Corporation (a Fansteel affiliate) in numerous high temperature operations in the production of tungsten and molybdenum metals and tantalum-tungsten carbide materials for cutting tools and wire dies.

The Alundum Tubes directly support the resistor wire; they meet severe temperature conditions; they permit the easy maintenance of reducing atmospheres, they conduct heat rapidly; they have low coefficient of expansion due to heat; they do not conduct electricity even at elevated temperatures.

If you use high temperature electric furnaces in the laboratory or for commercial production we'll be glad to tell you more about Alundum Tubes and Cements.

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*Numerical expressions that are combinations of
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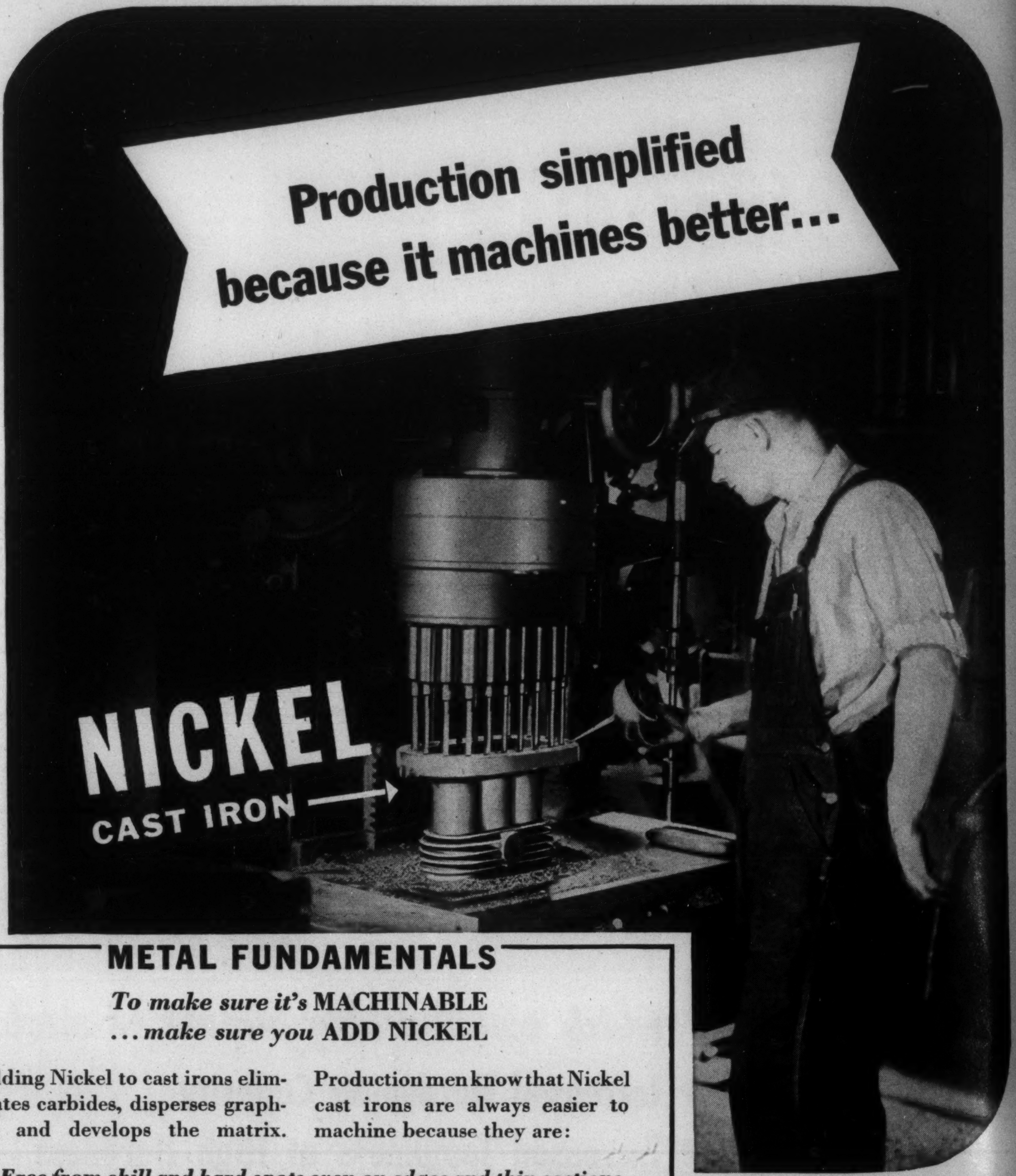


Photo courtesy of York Ice Machinery Corp., York, Pa.

METAL FUNDAMENTALS

To make sure it's MACHINABLE
... make sure you ADD NICKEL

Adding Nickel to cast irons eliminates carbides, disperses graphite and develops the matrix. Production men know that Nickel cast irons are always easier to machine because they are:

1 *Free from chill and hard spots even on edges and thin sections.*

2 *Free from porosity, shrinkage and open grain that cause costly rejects during and after machining.*

3 *Dependably uniform in hardness and structure through thick and thin sections.*

4 *Of maximum machinable hardness.*

5 *Fine grained permitting mirror-smooth finish.*

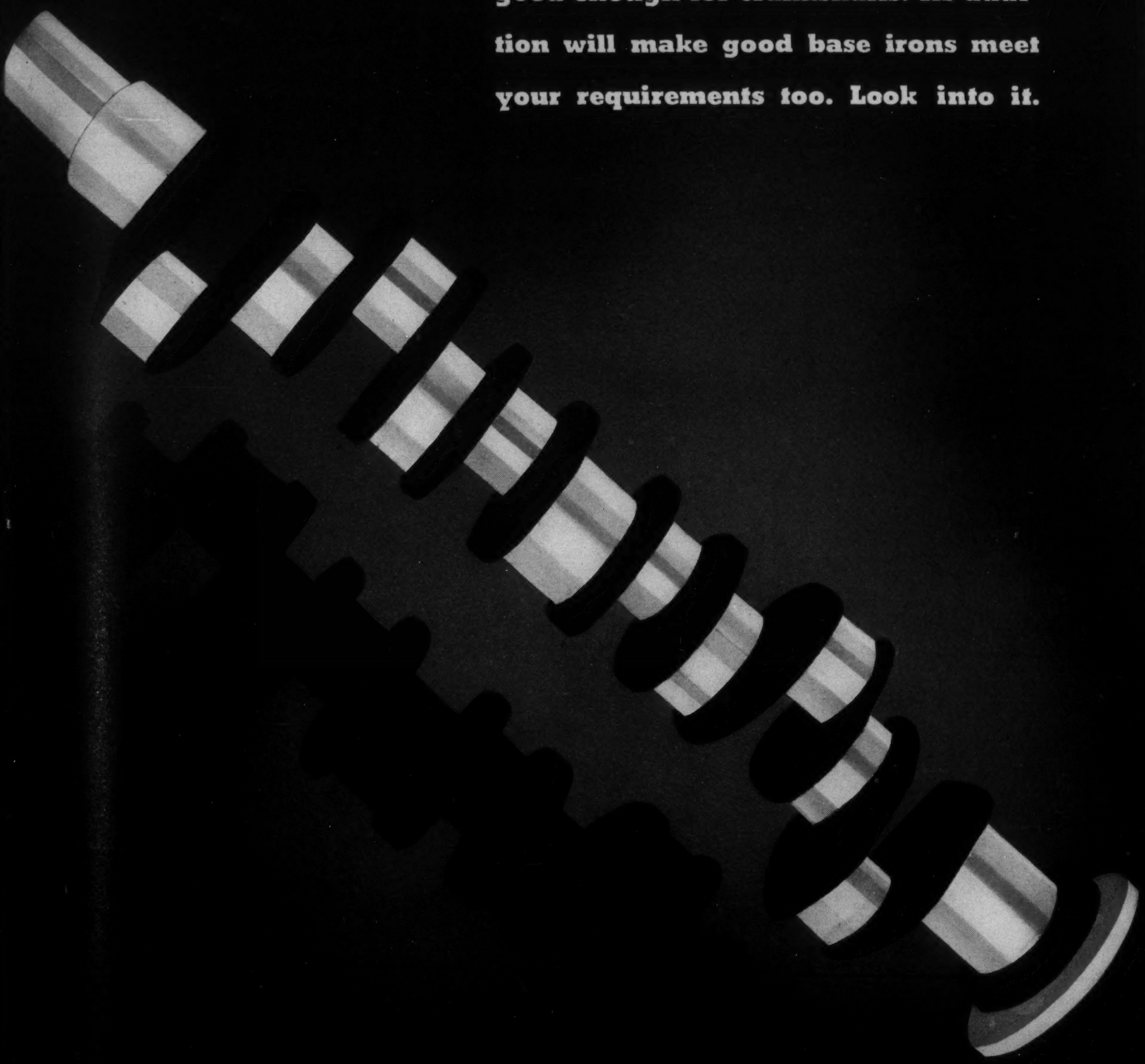
Producing cylinder blocks or other castings with sections of varying thickness, a manufacturer's first thought is machinability. From long experience, he depends upon Nickel alone or in balanced combination. He knows Nickel added to cast iron assures improved machinability and uniformity of structure, plus higher strength and wear resistance in finished parts.

• • •

Your consultation on applications involving Nickel alloyed irons is invited.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK, N. Y.

Molybdenum makes good gray iron good enough for crankshafts. Its addition will make good base irons meet your requirements too. Look into it.



MOLY

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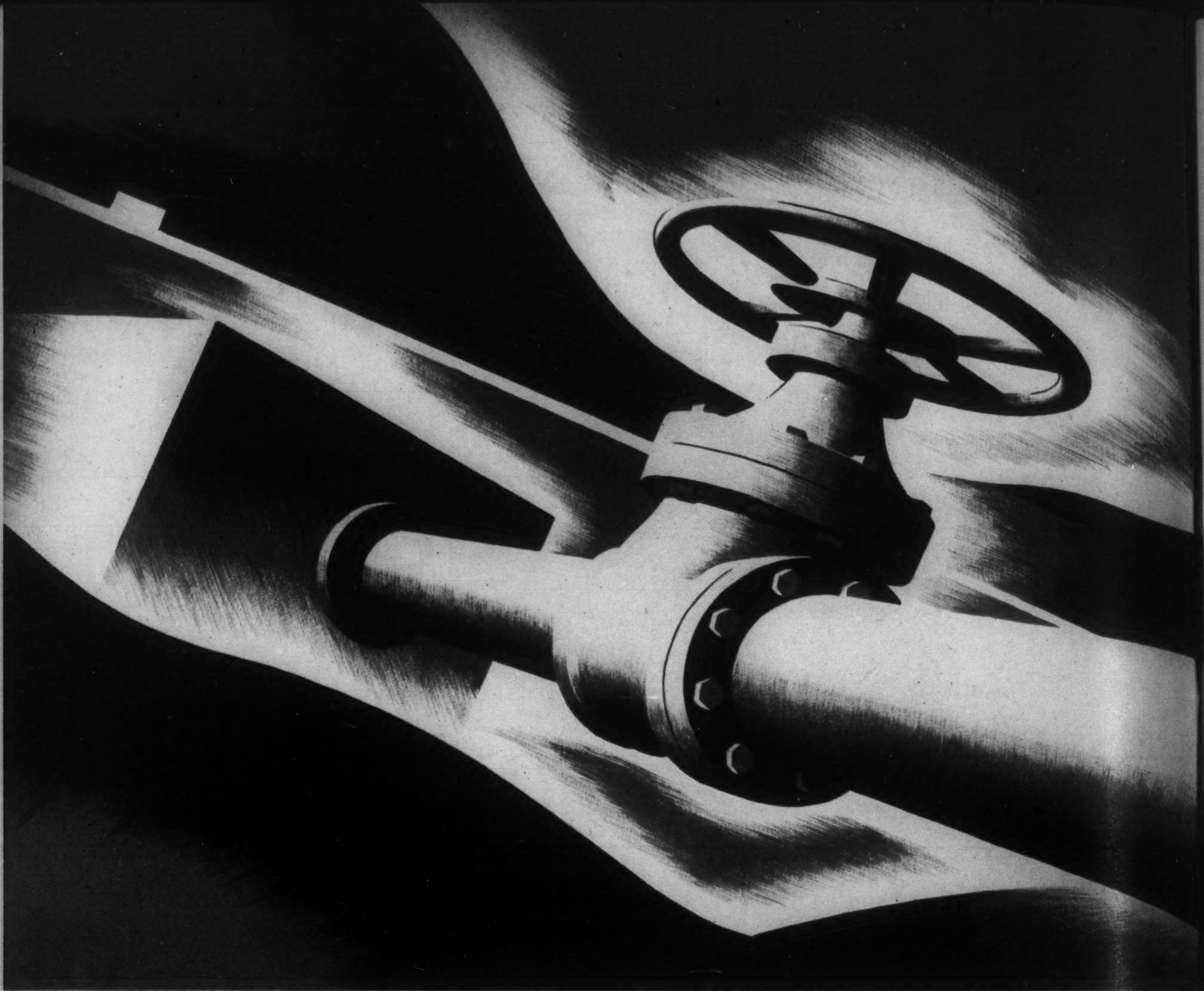


CONDITIONS, TOUGH . . . SOLUTION, EASY

Crude oil pipe-line service imposes severe requirements on the valves, particularly those used at pumping stations, river crossings and other points to permit sectionalizing of the line. Working pressures are high. Continual expansion and contraction of long pipe lines put heavy loads on the valve flanges.

These severe conditions have been met with entire satisfaction by 10" valves made of Molybdenum cast iron (0.50% Mo). The iron is noteworthy for the uniformity of structure and properties when cast in heavy sections. It makes valves that test pressure tight at double the working pressure of 800 pounds. Tensile strength is 48,000 p.s.i.

You may well be able to apply this iron or one of the other Molybdenum irons to advantage. Our technical book, "Molybdenum in Cast Iron", giving full practical data, will be sent free on request to interested engineers and production executives.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

MOLY

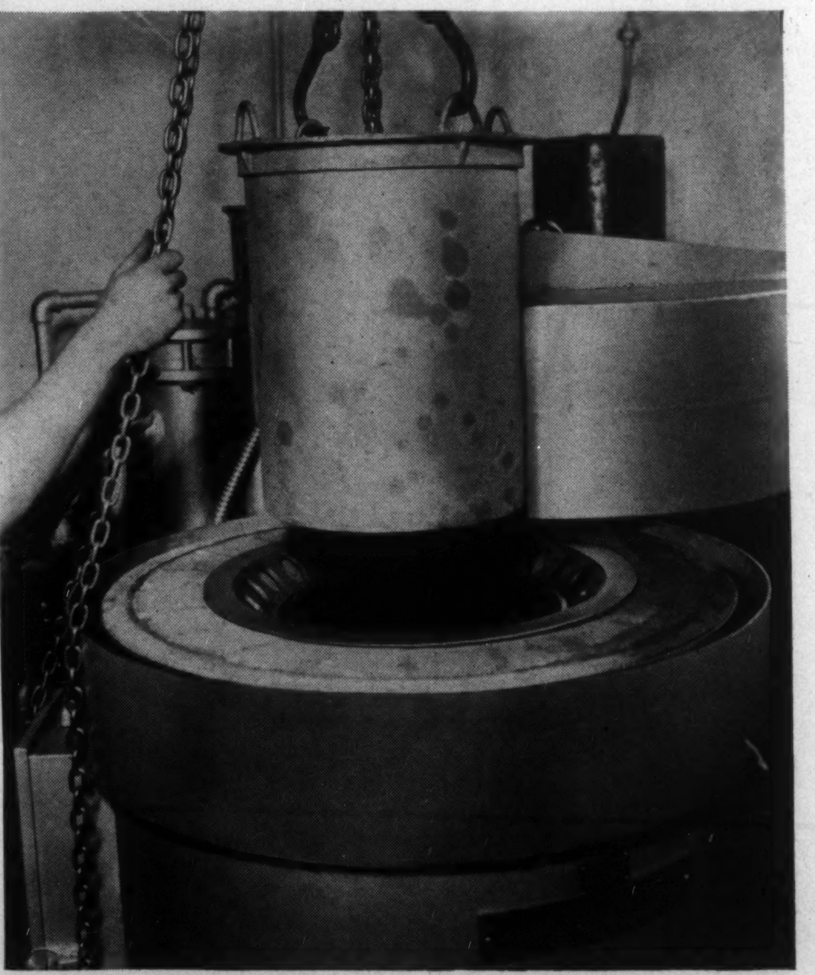
Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

Nitriding Equipment...

STILL GOOD AFTER 6 YEARS' SERVICE

(left) *Bell type furnace hood (on crane hook) of Inconel used in Nitriding. (Courtesy — Westinghouse Electric & Mfg. Company.)*

(below) *Basket of Inconel used in Pit Type Nitriding furnace. (Courtesy—Westinghouse Electric & Mfg. Company.)*



Containers and separating screens made of Inconel, stand up against heat and corrosion

EXCEPTIONALLY suitable for nitriding equipment is the heat and corrosion resistant alloy, Inconel. Containers of Inconel like those illustrated have been used as long as six years . . . and still good for further service.

Screens for separating small parts during nitriding are also made of Inconel, in the form of expanded metal or wire cloth. Such screens permit free access of gases to all parts. Tubing employed for conveying ammonia gas into containers is also made of Inconel or Pure Nickel.

Write for further information on use of Inconel for nitriding equipment. Ask also for Bulletins T-7, "Properties and Uses of Inconel" and T-8, "The Welding of Inconel." Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York, N. Y.

Inconel is a registered trade-mark of The International Nickel Company, Inc., which is applied to a nickel alloy containing approximately 80% Nickel with additions of chromium and iron.

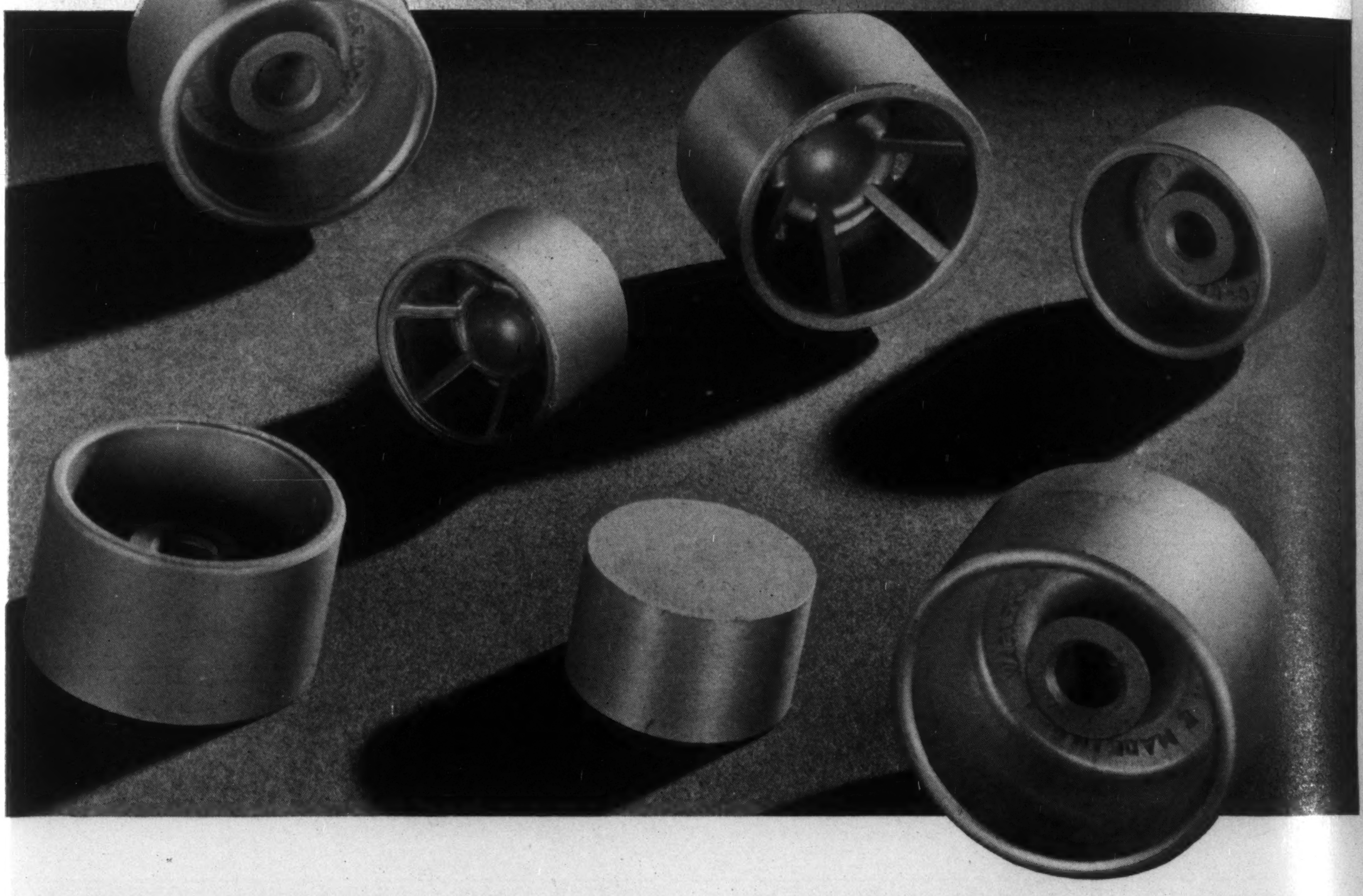
INCONEL

ADVANTAGES OF INCONEL AT HIGH TEMPERATURES

1. High strength and ductility maintained.
2. Makes ductile welds, not subject to intergranular deterioration.
3. Free from excessive distortion during sudden temperature changes, due to low coefficient of thermal expansion.
4. Withstands constant vibration owing to high fatigue limit.
5. Highly resistant to a wide range of corrosive conditions.
6. Very resistant to oxidation, even at high temperatures. Oxide adherent and does not scale off.
7. Can be formed readily into complicated shapes.
8. Mill forms and welding rod available from mill stocks.

WHEN THESE FELLOWS GO TO WORK..

you STOP!



They're hydraulic brake pistons. One, quite likely, matches those that make your car a safer car to drive.

They're Alcoa Aluminum press forgings. Formed with all their fine detail in a single stroke of the press, very little machining is required before they're ready to go to work. The finished Aluminum pistons cost car manufacturers less than those made of any other metal, that's suited to the job.

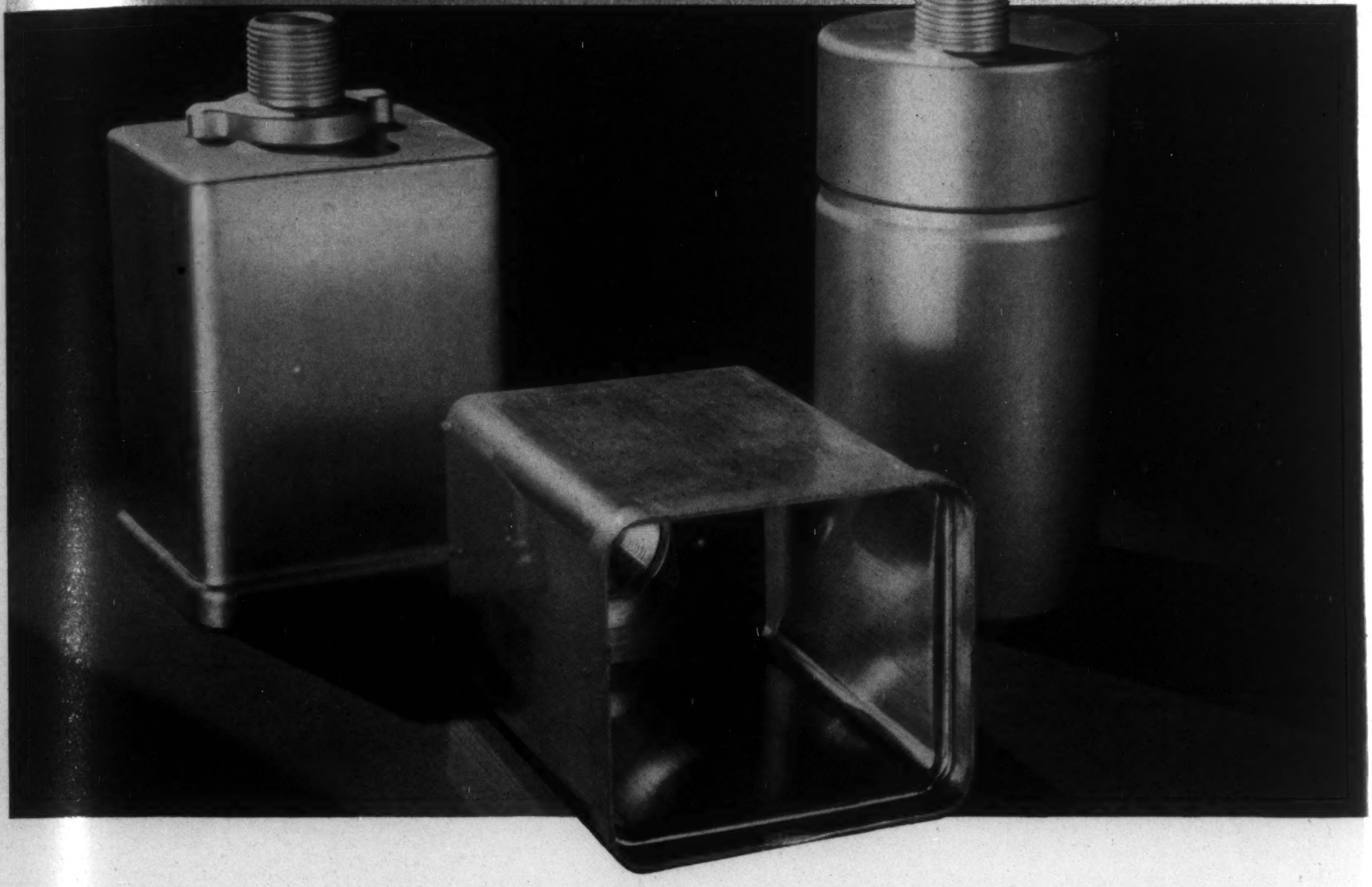
Note the sharpness of the edges, the ribs and lettering deep down inside these pistons. That kind of workmanship is typical of what you can expect of Alcoa press forgings. They can be made in a variety of Aluminum Alloys, suiting their characteristics to your use. We'll welcome your inquiries. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh, Pa.

ALCOA ALUMINUM

It is thrifty to use Alcoa Aluminum wisely

ALCOA·ALUMINUM

THESE ARE IMPACT EXTRUSIONS



Capacitor cans, made on the impact extrusion press, are finished simply by trimming to length, cutting the threads and rolling the crimp (in the round piece). What a saving in time and money over old production methods!

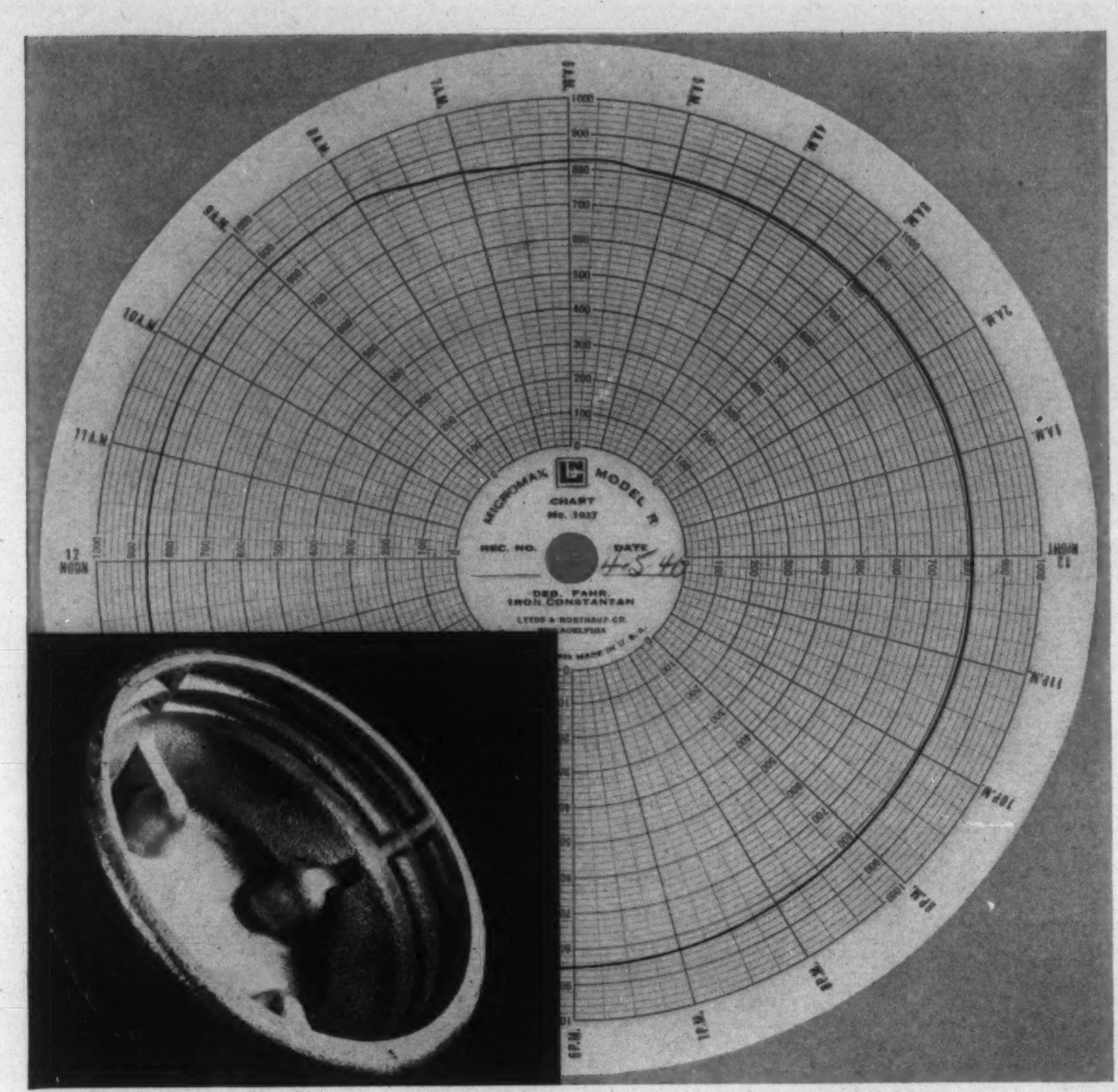
Impact extrusions, made of Alcoa Aluminum Alloys, have enabled many manufacturers to cut costs and improve their products. Parts, originally designed for drawing, stamping, spinning, or as assemblies, can often be altered to take advantage of the benefits of the economical impact-extrusion process.

With Alcoa impact extrusions, tolerances are close, the metal is uniform and dependable, mechanical properties are good. Walls can be thinner than bottoms; projections or embossing can be included on bottoms, and, on certain types, walls can be ribbed. All of the other advantages of Aluminum are retained; light weight, resistance to corrosion and fine appearance.

Send for the book, "Impact Extrusions and Pressings." It may suggest means of adapting your products to this process. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh, Pennsylvania.

It is never costly to use Alcoa Aluminum right

ALCOA·ALUMINUM



Typical steel part, galvanized by Charles E. Schuler Engineering Co., Newark, Ohio; and a typical day's record showing the close Micromax control of temperature.

Gets $50 Free Fuel Every Month By Using Micromax Furnace Control

It would cost the Charles E. Schuler Engineering Co., Newark, Ohio, just fifty dollars a month to disconnect the Micromax Electric Control on their galvanizing-pot furnace. They know this because the furnace was purchased without the control and was, for a time, regulated by its operator. When Micromax Control was added, the bills for gas fuel dropped $50 a month, and remain consistent.

A Super-Human Controller

The reason Micromax runs a furnace more cheaply than a man could do is that it's more constantly attentive to heat, and more responsive, than any man could be. It catches the first tiny temperature change, when no man could see the motion of the pyrometer, and moves the valve in exact proportion. And, if the change is due to a shift in load, outside temperature, etc., Micromax automatically resets itself to correct the interference. . . . The standard Micromax fits any furnace. Write for Broadside N-33.

New Fitting Lets Rayotube Penetrate Furnace Flame

How to measure the temperature at the actual surface of a piece of metal while it is in a furnace is now fairly well known, providing there's no smoke, flame, etc., in the way. Either an L&N Optical Pyrometer or a Rayotube can be aimed at the work to secure a quick check, and if automatic record or control is wanted, a Rayotube is used, connected to a Micromax or Speedomax Pyrometer. But ......

LEEDS & NORTHRUP COMPANY, 4925 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

2½ Tons A Shift Drawn To Closest Limits In Homo Furnace

Five thousand pounds per shift, with almost never a reject, is the output of this Homo Tempering Furnace in the Atlas Ball Company's plant.

Load densities vary widely, because balls range in size. Tempering heat also varies, as does the size of load. To meet these and other conditions, the tempering of each batch must receive individual consideration; must hold the correct temperature; must be proved correct.

Homo Ends Tempering Guesses

This situation is made to order for Homo tempering. The heat-treater simply turns the Homo Controller dial to the desired temperature, loads the furnace, and goes about his other work. Results are, within commercial limits, perfect and are automatically recorded, for the assurance of everyone concerned.

Atlas Ball Co., Phila., Pa., tempers its entire output by the Modern Homo Method.

Homo furnaces are available for all tempering operations, for nitriding and for carburizing to within limits that may even give you a new idea of quality control. Send for a catalog or other information on the process in which you're interested.

. . . If smoke or flame are present, however, there's now a new answer which sometimes applies. This is to use an appliance which gives the Rayotube a clear sighting path directly to the surface of the work, practically regardless of the clearness of the furnace atmosphere. This appliance is comparatively simple. A description of it is available for anyone to whose problem it applies. For a general description of Rayotube, ask for Catalog N-33B.

Jrl Ad NT-0600C(4)

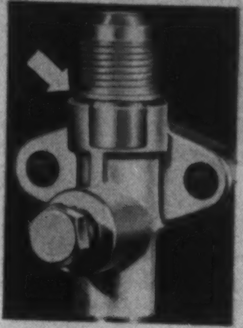
These jobs changed to SIL-FOS *or* EASY-FLO *brazing because*

. . . SIL-FOS and EASY-FLO offer many opportunities to improve joint quality at a reduction in cost that was not possible before these low temperature silver brazing alloys were developed.

With many, the change to SIL-FOS or EASY-FLO brazing was the outgrowth of cooperation between our brazing specialists and manufacturer's engineers.

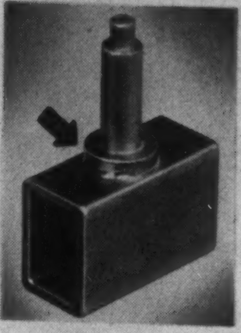
If ferrous, non-ferrous or dissimilar metal joining is part of your production, find out what SIL-FOS or EASY-FLO can do for you. Write for full details, or ask to have a service engineer call at your plant and go over your metal joining operations.

. . . EASY-FLO speeded up production and greatly reduced rejects, as compared to the high temperature alloy formerly used to braze this



REFRIGERATION VALVE

. . . Replacing a casting, SIL-FOS brazing cut costs, reduced weight, made a far better looking finished part of this

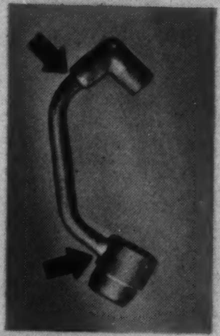


SLIDING BRACKET

. . . EASY-FLO brazing in place of soft solders gave higher strength and reliability under high operating temperatures to joints in this

AUTO ENGINE OIL FLOAT

. . . EASY-FLO ended trouble with leaking joints, saved time and expense in brazing three different metals (steel, copper, brass) in this

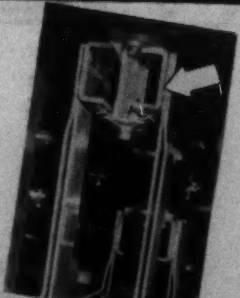


REFRIGERATION ASSEMBLY

. . . EASY-FLO brazing replaced welding, gave high strength, neat joints and eliminated finishing expense in mounting these

CONDENSER STUDS

. . . SIL-FOS brazing in place of clamped joints saved metal, increased electrical efficiency, eliminated joint maintenance in this



BUS BAR SYSTEM

Always use **HANDY FLUX** with SIL-FOS and EASY-FLO. It's the only way to get the full benefit of the low working temperatures of these alloys.

HANDY & HARMAN · 82 FULTON ST., NEW YORK

HANDY & HARMAN
FOUNDED 1867
QUALITY SERVICE

Agents in Principal Cities. In Canada: HANDY & HARMAN of Canada, Ltd., Toronto

CHARTREUSE

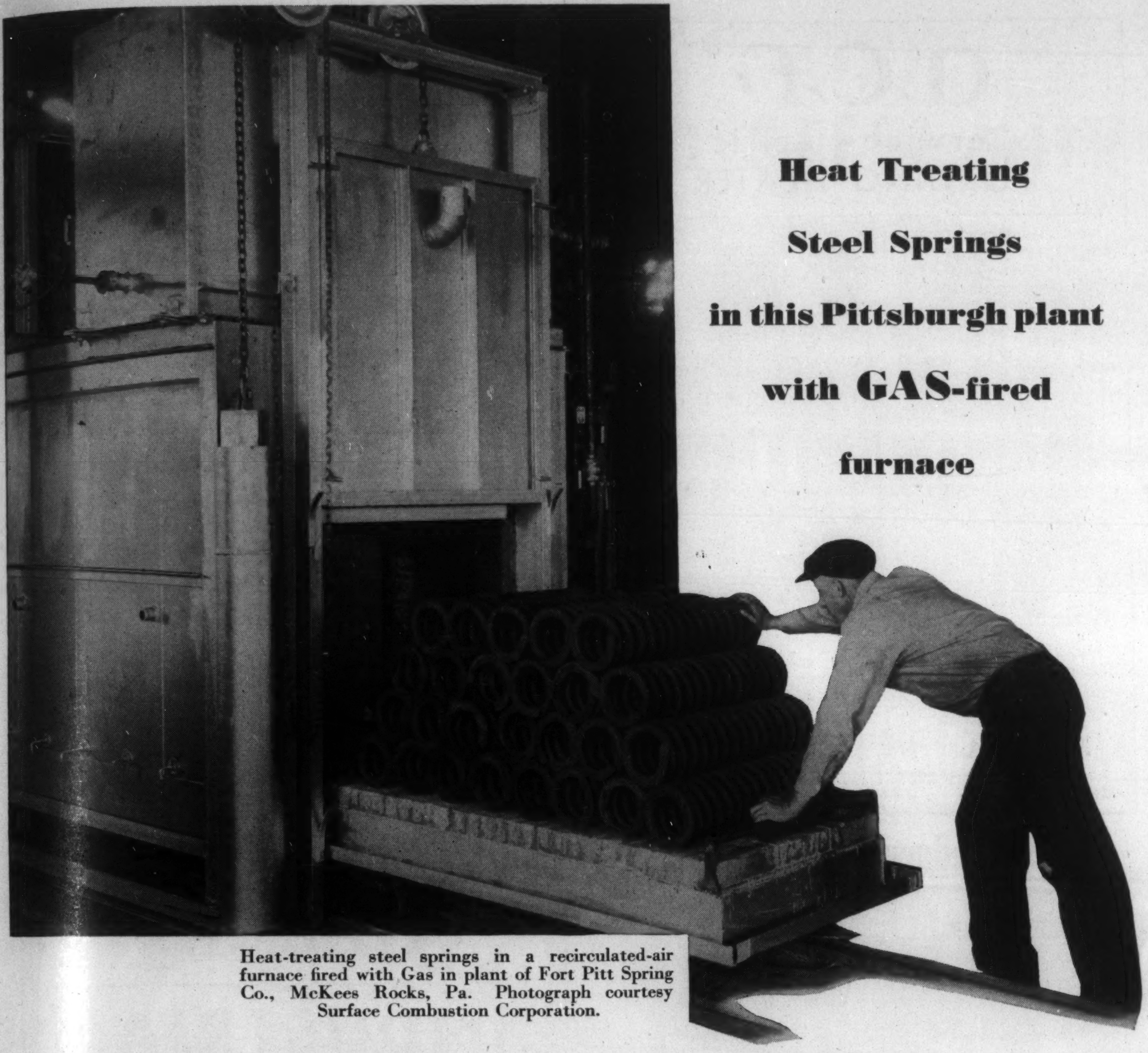
Whitey Sez:

"Many a dangerous temptation comes to us in fine gay colors that are but skin deep... Beneath the pastel coatings of Maurath Rods is an alloy wire ultra rich in vitamin-B qualities."*

* BONDING QUALITIES

MAURATH, INC., CLEVELAND

BUILDER OF BETTER WELDING ELECTRODES IN ALL ANALYSES



Heat-treating steel springs in a recirculated-air furnace fired with Gas in plant of Fort Pitt Spring Co., McKees Rocks, Pa. Photograph courtesy Surface Combustion Corporation.

Heat Treating
Steel Springs
in this Pittsburgh plant
with GAS-fired
furnace

The advantages of heating by means of recirculated air—with Gas fuel—are becoming accepted more and more by industry. Here is shown a typical recirculated-air furnace used in heat-treating in the plant of the Fort Pitt Spring Co., McKees Rocks, Pittsburgh—further evidence of the efficiency and other values of Gas fuel in the tempering of metals within narrow ranges of temperatures.

The wide acceptance by the heat-treating industry of convection heating is due to inherent characteristics which make possible a heating rate and temperature uniformity seldom otherwise attained. Recirculating the heated air and products of combustion results in high thermal efficiency and opens the way to higher production qualities and greater uniformity.

Whatever your method of heat-treating, you will find it more accurately controllable and less costly with Gas fuel.

See what Gas can do. Ask your Gas company for full information.

THE TREND TODAY IS TO GAS
FOR ALL
INDUSTRIAL HEATING

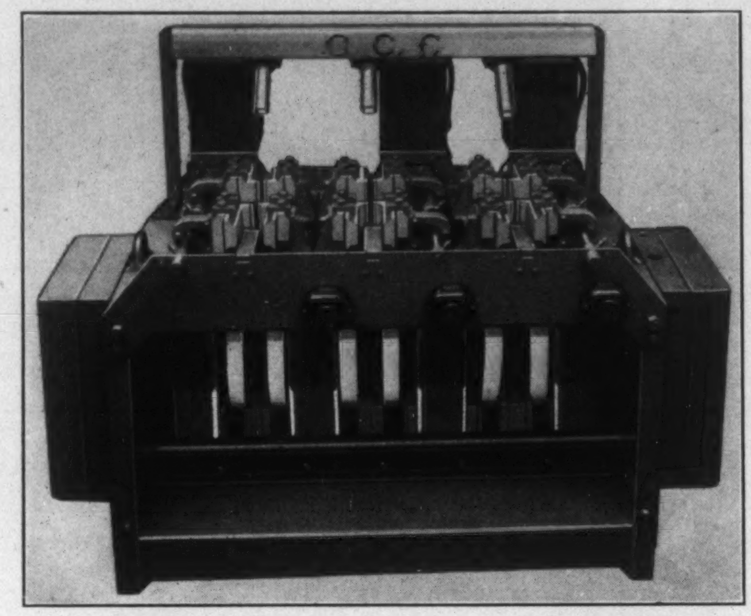
AMERICAN GAS ASSOCIATION

INDUSTRIAL GAS SECTION

420 LEXINGTON AVENUE, NEW YORK CITY

a.c.f.

Berwick Electric
FORGING HEATER



For heating bars—diameter ⅛"—2½". Water-cooled electrodes—electric eye to regulate temperature—high speed reduces scale to minimum. Write for recommendations.

AMERICAN CAR AND FOUNDRY COMPANY

30 CHURCH STREET . . . NEW YORK, N. Y.
CHICAGO DETROIT ST. LOUIS

Therm-O-Flake

Therm-O-flake

COATING

SUPERIOR HIGH TEMPERATURE INSULATION

Keeps heat inside, with a coating of plastic insulation.

One inch thickness equivalent to about nine inches of fire brick wall in insulation value.

More economical in cost and installation, on existing furnaces, than walls of insulation brick.

Easily applied and largely reclaimable for re-use, after removal.

Most widely used material for high temperature insulation, up to 2000°F.

●

Write for Information and Prices

Other Therm-O-Flake Products

● Made from Exfoliated Vermiculite

Granules, Brick, Block, Concrete

Illinois Clay Products Company

JOLIET, ILL.

Want to Reduce Annealing Costs?

KENNAMETAL Cuts Hardened STEEL
Like a HOT KNIFE Cuts Butter

KENNAMETAL

STYLE NO. 11 TOOL
with Chip Breaker

Machinists like KENNAMETAL because it machines steel 2 to 6 times faster than high speed steel tools, removes 10 to 50 times more metal per tool grind and can take jump cuts without breakage.

Plant metallurgists like KENNAMETAL because it reduces fabricating costs all down the line. KENNAMETAL machines steel of all hardnesses up to 550 Brinell—often eliminating annealing operations—and the resulting finish is so smooth and accurate that it is usually unnecessary to grind or polish after machining.

If production costs form part of your responsibilities—investigate KENNAMETAL steel cutting tools without delay. Write for our new catalog describing 20 standard style KENNAMETAL-tipped tools for every operation.

McKENNA METALS Co.
158 LLOYD AVENUE
LATROBE, PENNSYLVANIA, U.S.A.

STEWART

INDUSTRIAL FURNACES of all kinds

FORGING, HEAT TREATING, METAL MELTING, ETC.

●

CAR TYPE FURNACES, CONVEYOR FURNACES and the STEWART GASIFIER

●

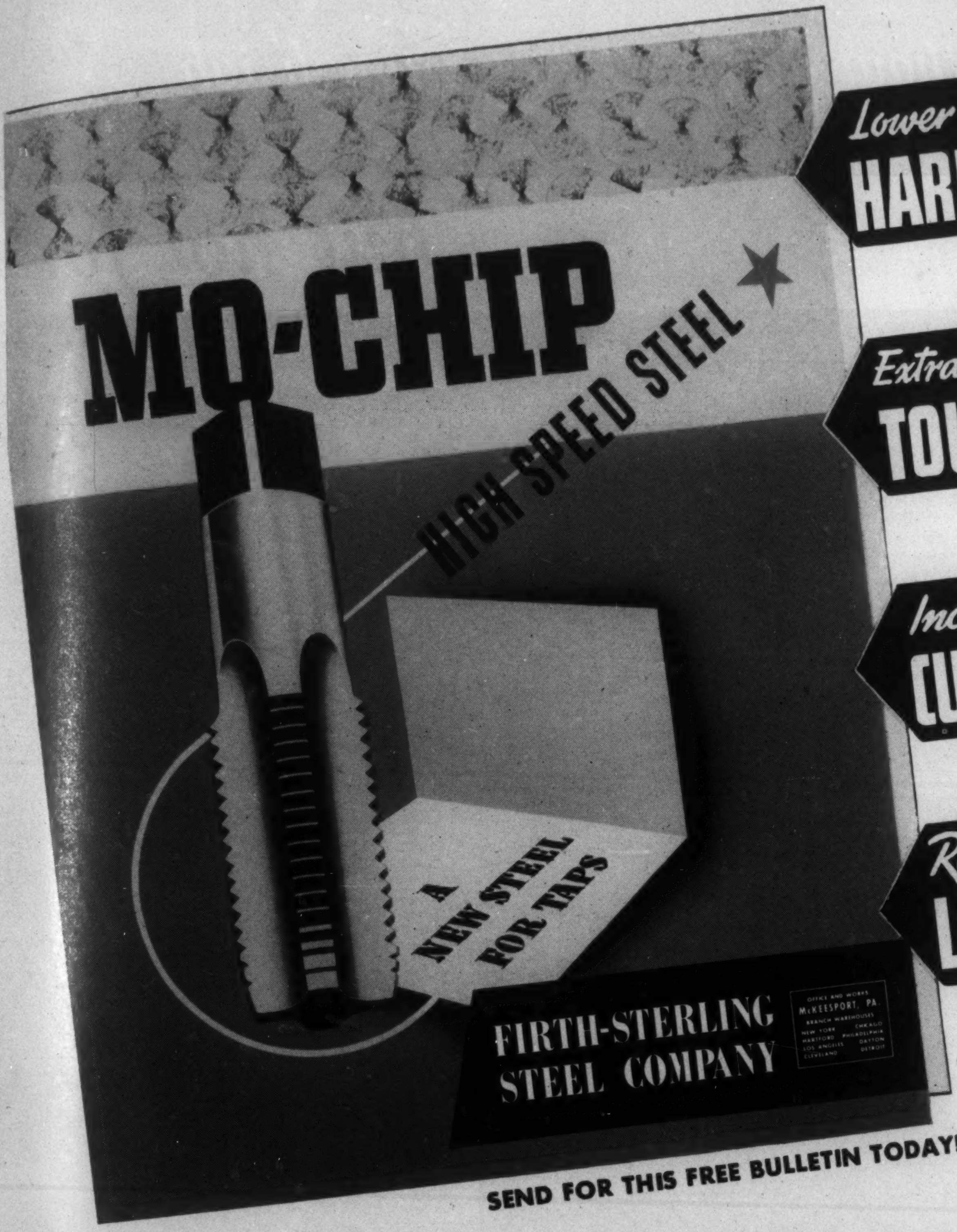
A Stewart representative is located near you. Let us know and we will see that he gets in touch with you quickly.

CHICAGO FLEXIBLE SHAFT CO.

1103 South Central Avenue, Chicago, U. S. A.
FLEXIBLE SHAFT CO., Ltd., 321 Weston Rd., S., Toronto, Ontario, Can.
Eastern Branch Office: 11 W. 42nd St., New York, N. Y.

Tool makers asked for it... here it is!

A NEW HIGH SPEED STEEL WITH


MO-CHIP
HIGH SPEED STEEL
A NEW STEEL FOR TAPS
FIRTH-STERLING STEEL COMPANY
OFFICE AND WORKS McKEESPORT, PA.
BRANCH WAREHOUSES
NEW YORK CHICAGO
HARTFORD PHILADELPHIA
LOS ANGELES DAYTON
CLEVELAND DETROIT

Lower **HARDENING HEAT** ★

Extraordinary **TOUGHNESS** ★

Increased **CUTTING CAPACITY** ★

Relatively **LOW PRICE** ★

SEND FOR THIS FREE BULLETIN TODAY!

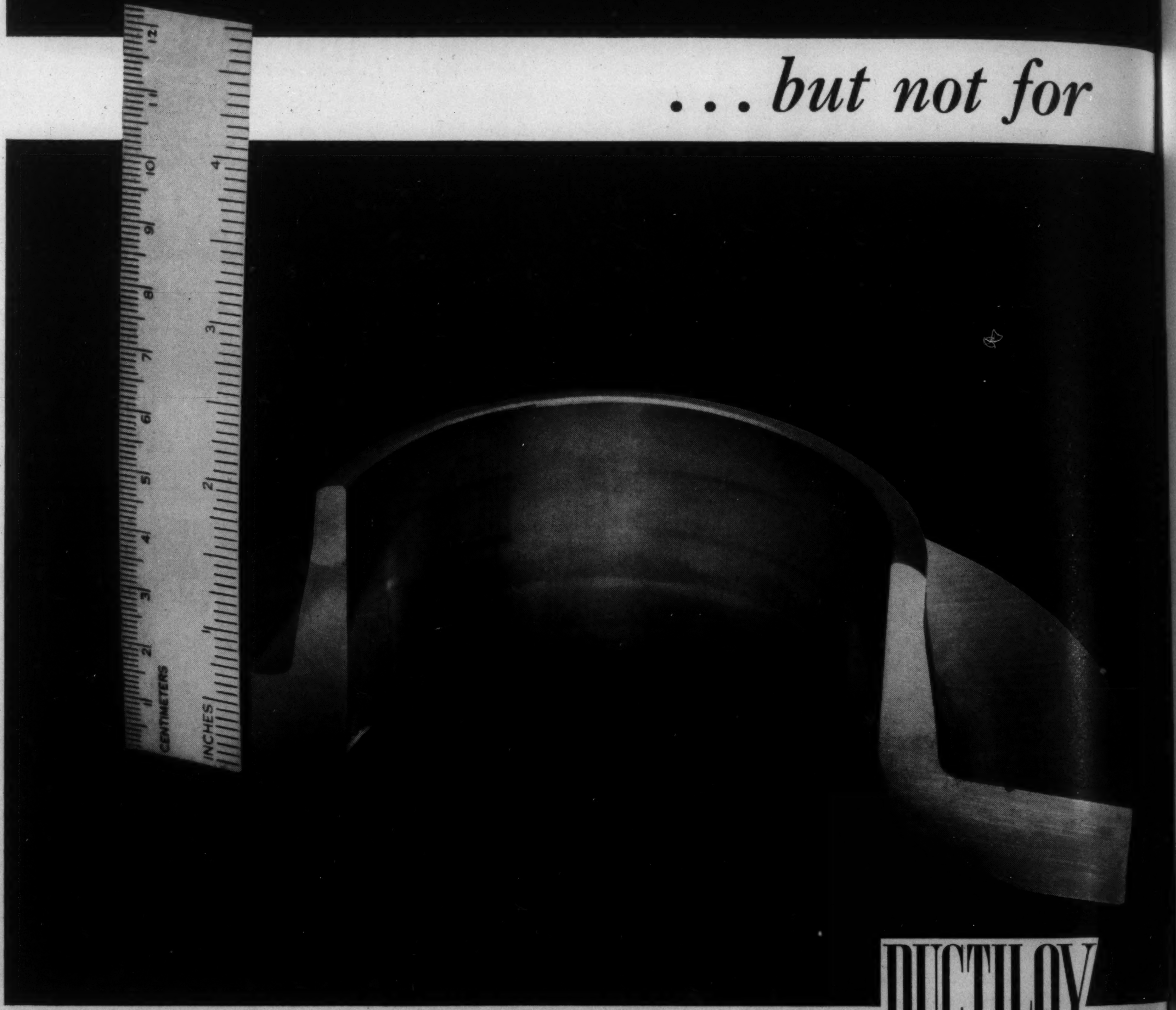
MO-CHIP is *not* just another substitute for High Speed Steels of the Tungsten-Molybdenum Type. It is a NEW alloy developed expressly to overcome breakage and other difficulties encountered by manufacturers of *taps, threading dies, broaches, forming tools* and similar products. Send today for the new MO-CHIP Bulletin, illustrated above, which contains full technical information.

FIRTH-STERLING STEEL COMPANY

OFFICE AND WORKS:
McKEESPORT, PA.
BRANCH WAREHOUSES:
NEW YORK CHICAGO
HARTFORD PHILADELPHIA
LOS ANGELES DAYTON
CLEVELAND DETROIT

Sure,
cold forming $5/8$-inch high tensile plate
without annealing is a tough job

. . . but not for



This automotive production part was cold formed from $5/8$-inch DUCTILOY plate in four draws without intermediate annealing.

DUCTILOY

ITS INHERENTLY FINER GRAIN MAKES ALL THE DIFFERENCE

"SALEM" is prepared for defense!

The WITTER PROCESS FOR FORGING SHELLS

- SAVINGS IN MATERIAL
- SPEED OF PRODUCTION
- HIGH QUALITY
- LOW OPERATING COST
- SMALL FLOOR SPACE REQUIREMENTS
- MINIMUM MAINTENANCE COST

Complete Equipment for SMALL ARMS AMMUNITION

ANNEALING, PICKLING, WASHING & DRYING SMALL ARMS COMPONENTS - FULLY AUTOMATIC - MATERIAL NOT HANDLED BETWEEN CHARGING AT ANNEALING FURNACE AND DISCHARGING AT DRYER - UP TO 50 CALIBER CARTRIDGE CASES EQUIPMENT FOR ANY BRASS DEEP DRAWING OPERATION

Consultants - Engineers - Builders

COMPLETE ORDNANCE PLANTS

And Special Forging Plants

These specialized "Salem" Services are vitally important to the production of Ordnance and Small Arms Ammunition and are backed by complete technical and operating experience.

ROTARY HEARTH FORGING FURNACES
BATCH TYPE FORGING FURNACES
ROTARY END HEATING FURNACES
BOX TYPE END HEATING FURNACES
HARDENING, QUENCHING, and DRAWING EQUIPMENT

HEAT TREATING EQUIPMENT, FOR AIRCRAFT PARTS

"Salem" designs, contracts, builds and offers consulting service.

●

All "Salem" Ordnance and Small Arms Equipment is readily adaptable to commercial production—in many cases without modification.

SALEM ENGINEERING COMPANY

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SALEM ENGINEERING COMPANY

CURRENT news

A New Electric Steel Plant

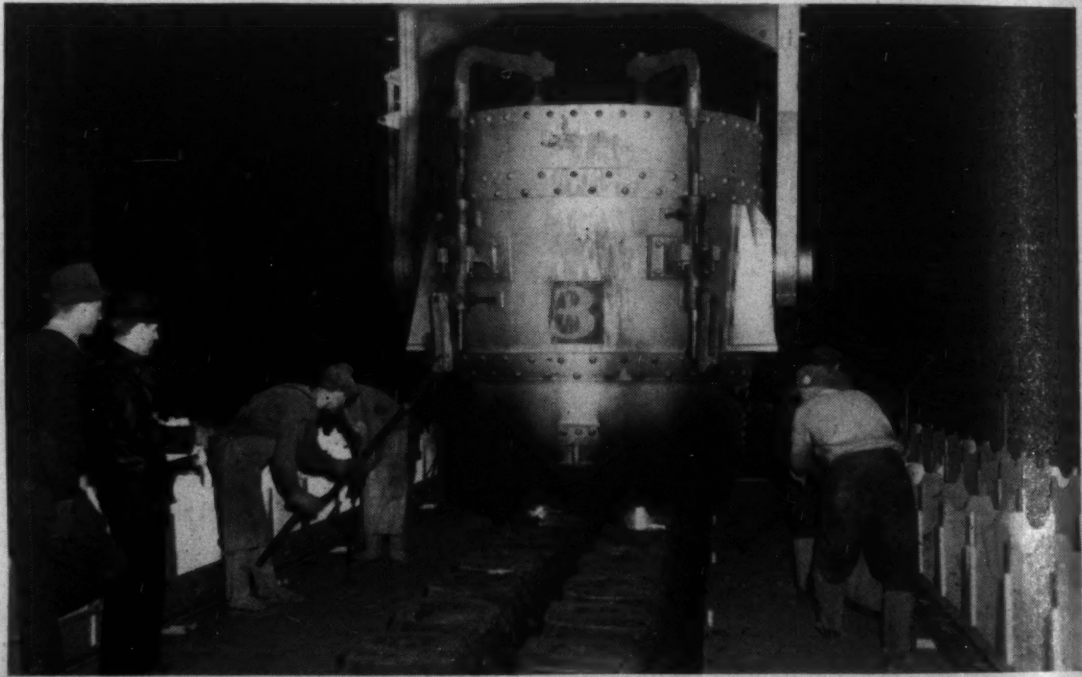
FOR the purpose of producing for the general market all types of high-grade carbon and alloy steels, a new plant has been erected at Warren, Ohio, by the Copperweld Steel Co., of Glassport, Pa. The product is exclusively high-grade electric furnace steel in the form of billets and bars. The latest modern equipment has been installed for melting, heating, heat-treating and rolling. The plant was quite recently put in operation.

The Glassport plant of the Copperweld Steel Co. produces copper-clad steel products exclusively. Ultimately the Warren plant will furnish this mill with the steel bars or billets which are now purchased in the open market. The rest of the Warren output, about 10,000 tons per month, will be sold as high-grade electric steels for aircraft forging and other steels.

Frederick J. Griffiths
Executive vice president

Personnel

Nothing has been spared to make the new plant at Warren strictly modern in equipment. It is manned by a personnel of long experience in the manufacture of alloy steels. The Executive Vice President is Frederick J. Griffiths, long an outstanding figure and pioneer in the alloy steel industry. The Vice President and in Charge of Sales is Sidney D. Williams, formerly director of sales for the Timken Steel & Tube Division of the Timken Roller Bearing Co., Canton, Ohio. Floyd Stroup is superintendent of the melting department. His experience has been gained with the American Steel Foundries, Central Alloy Steel Co., Republic Steel Corp., Timken Steel & Tube Co., United Engineering & Foundry Co. and Aetna Standard Engineering Co.



Pouring a heat of electric alloy steel on the teeming platform. Two molds are poured simultaneously from the double stoppered ladle.

(Below) Tapping a heat from one of the 25-ton Swindell-Dressler electric arc furnaces.

Melting Equipment

The melting equipment includes two 25-ton and one 6-ton electric arc furnaces. The 25-ton furnaces are the latest Swindell-Dressler type with removable roof for top charging. The 6-ton furnace is a "Lectromelt" type, for use in making special small heats. A feature of the electrical equipment is that the large furnaces are equipped with the largest transformers (in rated capacity) which have so far been used on this size of furnace. The high transformer capacity is claimed to result in very rapid melting of the charge, giving a longer time for the all-important refining period.

Removing an alloy steel ingot from the special ingot heating furnaces.

The present melting capacity is about 12,000 tons of ingots per month. The plant is so laid out, however, that additional electric furnaces can be installed.

Ingots weighing 2,100 lbs. were chosen to obtain quick freezing with fine crystallization, resulting in closer control of grain size with a minimum of segregation. Fluted molds of special design are used. A special method of preheating and handling the hot tops on the teeming platform is a feature.

Rolling Equipment

The blooming mill is a 29-in. 3-high type of heavy construction. Then there are 4 bar mills —a 24-in., an 18-in., and the 12-in. and 9-in. mills. The 24-in. mill is a 3-high mill, provided with both shearing and hot saw equipment. The 18-in. mill consists of two 3-high and one 2-high stands, also equipped with a hot saw. In the 12-in. and 9-in. bar mills, there are 5 stands of 12-in. and 2 stands of 9-in., with a double cooling bed 210 ft. long.

Heating Furnaces

For heating the ingots, which come direct from the stripper by special handling equipment, there have been built ingot heating furnaces of new design, provided with 3 doors each. The ingots stand upright in these furnaces which are heated with gas.

The method of firing these furnaces is pointed to as unique. There is a battery of 10 burners in the rear wall throwing a luminous flame under the arch toward the doors, with flues arranged to draw the incandescent gases in front of the doors and back through the rows of ingots, resulting in unusually even heating of the ingots. Automatic furnace temperature control is provided.

The Laboratory

The metallurgical and chemical laboratory is centrally located in the plant in a separate building. It is equipped with all the latest apparatus available and is modern in every respect. The chief metallurgist is W. J. Buechling; Ray F. Lab is the chief chemist. Both were formerly employees of the Central Alloy Steel Corp. and the Republic Steel Co.. By special pneumatic tubes, samples are quickly dispatched to the laboratory from the melting department.

In General

The working floor area under roof, in modern daylight buildings and completely served by cranes, is over 320,000 sq. ft. or about 7½ acres. The rolling mills will handle approximately 20,000 tons of finished steel per month. The products are billets, bars, and coiled rods from ½ in. to 8 in. Larger or irregular sections are pressed. The grades manufactured are all S.A.E. alloy steels, oxidation and corrosion resisting steels, aircraft quality steels, tool and special steels, and stainless steels.

The site of the plant is on a tract of 423 acres on the Mahoning River, 2½ miles north of Warren, Ohio. The plant is served by 3 railroads.

● At this writing the whole country, from Congress down (or up, depending on your viewpoint) is agitated over the question of where the aircraft industry is going to find sufficient capacity to meet the President's figure of 50,000 new airplanes a year. The Glenn L. Martin Co. at Baltimore has already found a "work simplification" program to be extremely helpful in increasing its own capacity during the period of the last year. The work simplification program, based on a schedule of supervisor-conferences, has effected savings in time from 32 to 68 per cent on the individual operation with, of course, a proportionately smaller saving in time and increase in capacity of production for the whole plant.

● U. S. Steel Corp. has released a new motion picture, "The Making and Shaping of Steel," which tells the story of steel from the time the ore is mined until the finished product leaves the mill. The film is 7 reels, black and white, sound on film, and is available in 16 or 35 mm. sizes. Film distribution centers have been established at Pittsburgh, Chicago, New York, Birmingham, Cleveland and San Francisco.

● The increasingly heavy consumption of aluminum has led to an additional contract by the Aluminum Co. of America with the Bonneville Power Administrator to permit doubling the capacity of the new aluminum-producing plant now under construction at Vancouver, Wash. The new plant, when finished, will thus be able to produce 60,000,000 lbs. of metal per year.

● At the 40th convention of the International Acetylene Association the following officers were elected: President, Henry Booth, Shawinigan Products Corp., New York; vice president, E. L. Mills, Bastian-Blessing Co., Chicago; treasurer, Philip Kearny, K-G Welding & Cutting Co., New York, secretary, H. F. Reinhard, Union Carbide Co., New York

● Carbide tools are now being widely used by airplane manufacturers in England for machining stainless steels and nickel-chromium-molybdenum steel, with shops machining shell forgings tooled up 100 per cent on carbide tools—according to A. H. Alexander, a British manufacturer visiting the McKenna Metals Co., Latrobe, Pa., manufacturers of 'Kennametal,' a cemented tungsten-titanium carbide.

Forthcoming Lincoln Award Contest

Readers who recall the first Lincoln Foundation Award program with the mass of useful and practical information about welding that it provided (and, of course, the extremely generous prize awards) will be interested to know that the Foundation is sponsoring a second award program.

The awards of the Industrial Program of the James F. Lincoln Arc Welding Foundation, as it is officially known, are for reports describing advances and improvements made between now and June 1, 1942, by fabrication, construction, welding service and maintenance. The product or structure may have arc welding actually applied to it within that period or it may simply be design or redesign within the same perod to utilize arc welding. In either case, each report is to include a design and description bringing out advances and improvements.

While the program is for the entire industrial field, it actually comprises 46 individual award programs. Each of the 46 divisions has 4 awards of its own and is automatically eligible for certain other awards in competition with best papers from other divisions. The individual cash prizes run from a minimum of $150.00 to a possible maximum of $13,700.00.

Details can be obtained from the James F. Lincoln Arc Welding Foundation, Cleveland.

"Flame Thrower" Hardens Crankshafts

An automatic "Flame Thrower" for producing main bearing surfaces of exceptional hardness with resulting long life and low oil consumption on the 85-lb. crankshaft of the 1940 Lincoln-Zephyr V-12 engine has been built by Lincoln Motor Co. engineers, using a lathe as the basis of their design.

An overhead lifting mechanism places the cast steel crankshaft in position and, as the shaft begins to rotate, oxyacetylene jets located in pairs at each of the 4 main bearing surfaces flare up automatically. After one minute, the gas is automatically cut off and water flows on the heated bearing surfaces from pipes above them. The crankshaft continues to rotate at about 200 r.p.m. throughout the quenching operation.

The timing of the beginning of automatic torch action depends on the location of individual bearing surfaces with respect to heat transfer conditions. Each bearing surface is heated to the same depth, with the torches being cut off simultaneously. The operator has merely to set the crankshaft in place and push a starting button. Only 3 min. are required for the entire operation, which is said to leave the bearing surfaces file-hard but not brittle.

Larger Drill Shanks by Brazing

Recently in a mid-west plant a need came up for larger shanks, ½ to ⅝ in., on some 3/16 and 5/16-in. straight shank drills. The expense involved in making up special drills caused this company to look for an inexpensive way of building up the shanks. After considerable experimenting, a method of brazing with a low temperature silver alloy was tried and the job worked out satisfactorily,

New cold rolled steel shanks of the desired outside diameter were turned and drilled to give 0.002 to 0.003 in. clearance when the drills were inserted. The drill shanks and the holes in the new shanks were cleaned and fluxed and the drill inserted in the hole. A ring of silver brazing alloy was then placed around the drill. The shank was heated with a torch and when a dull cherry red color was reached the silver alloy, which flows freely at 1175 deg. F., flowed and penetrated between the drill and the new shank.

Several joints were then cut apart and they all showed that the brazing alloy had penetrated throughout the joint to the bottom of the hole in which the drill had been inserted. The two parts were bonded firmly together. Further tests under severe operating conditions resulted in broken drills repeatedly without disturbing the brazed joints, it is reported. The heat required to do this job reached a dull cherry red, yet by confining it to the shanks and cooling the joint immediately after brazing, the hardness of the cutting end of the drill was not changed.

Light Armor Plate

One of the latest developments in the application of steel to wartime purposes is the use of light armor plate for the protection of airplane pilots from machine gun and anti-aircraft fire, according to the Jessop Steel Co., 546 Green St., Washington, Pa., who report that they have just completed shipment on a large number of sets of armor plate to be installed in the cockpits of combat planes, and so placed as to afford protection to fire from below and from the rear. Both pieces are curved to provide greatest possible comfort to the pilot; furthermore, bullets will also ricochet off the curved plate more readily than off of a flat plate.

The armor plate for this order was specially heat-treated to procure maximum ballistic resistance to penetration. As a result, it was possible to use a comparatively thin gage steel and thus reduce weight of the pieces to a minimum, while fully protecting the pilot.

The Jessop Steel Company also makes armor plate for use in police cars, payroll trucks, tanks, shields for banks and jails, and in other places where bullet-proof steel is needed. Sheets and plates can be furnished which will withstand 0.38 and 0.45 calibre pistol and submachine gun bullets, as well as 0.30 calibre Springfield Rifle fire. Complete information on Jessop light armor plate will be sent free upon request.

Graphitic Steel Gages

Extreme accuracy of dimension in many finished products often depends on the use of a large number of accurately-sized fixed gages. These must be made from steel of high wear resistance, good heat treating properties, high finish and resistance to dimension change during service. Machinability is vital to the economy of production of such gages.

It is reported by the Timken Roller Bearing Co. that tests on a large number of tool steels have shown that the graphitic steel known as "Graph-mo" possesses all the necessary structural properties, offers a saving of about 25 per cent in machining time, and, because of the lubricating properties of this steel, has no tendency to seize when checking a cavity smaller than the gage dimension. Graph-mo master gages, suitably aged and maintained at a uniform temperature, are said to be entirely satisfactory in meeting the larger problems of fabrication and maintenance associated with standard gages.

The present standard of hardness for such gages is 63-64 Rockwell C, which is obtained by quenching Graph-mo into oil from 1475 deg. F. to 1525 deg. F., depending on the cross section, and then tempering one or more times at 300 deg. F. for at least 4 hrs. Use of the recommended wheels in grinding the finished portions of these gages results in a flat, smooth, wear resistant surface, it is said. Worn sections can be built up by the resistance welding method, using a Graph-mo rod; this method is highly economical for snap gages.

● To clear up some of the present controversy and to aid in the establishment of reasonable standards with respect to the best designs for welded connections in the building field, the Engineering Foundation, research organization of the national engineering societies, has formed the Structural Steel Welding Research Committee. Basic data will be sought to enable fabricators to apply welding in building with greater safety and economy. The first of several research fellowships in the program has been assigned to Lehigh University for a 2-yr. period.

● The American Foundrymen's Association at its annual meeting in Chicago elected L. N. Shannon, Stockham Pipe Fittings Co., Birmingham, Ala., as its new president and H. S. Simpson, National Engineering Co., Chicago, vice president. New directors elected were H. S. Washburn, B. D. Claffey, George Cannon, H. J. Roast, and L. P. Robinson.

● The corporate title of Eisler Electric Corp. (Callite Products Division) has been changed to Callite Tungsten Corp., with plant and offices remaining at Union City, N. J. The new name is felt to reflect more accurately the company's business and policies, since the company specializes in refractory metals and their alloys and carbides for a variety of industries.

Melting Zinc for Aircraft Dies

Out of the kitchen has come the inspiration for the "latest important development in the metals industry"—the efficient melting of zinc in industry. The humble double-boiler with which Mrs. Smith cooks her vegetables to just the proper turn has been adapted, on heroic scale, to smooth the wrinkles from the brows of industrialists plagued with the expense and impurities of conventional methods.

Down at the great Glenn L. Martin Co., Baltimore, Md., aircraft factory (biggest in the United States, if not in the world) in Baltimore has been developed this useful system, because Martin uses much of the metal in making dies for his famous bombers and overocean transport ships. Patents on the device have been taken out by the company.

Heretofore, zinc has been melted simply by putting it in a pot and then putting fire under the pot. But heat has concentrated at certain points, the zinc has alloyed with the pot metal at these points, and the melted product usually turns up with impurities from the contact. In addition to this, the pots have been short-lived, eroding at the points of maximum heat—an expensive item indeed.

It was to produce better metal for die-making and at the same time reduce the cost of pot replacement that the Martin research staff, developed the double-boiler idea after 6 months of experiment. They built a big pot with a combustion chamber underneath (for gas, oil, or coal) and covered it with refractory material. In this they melt lead and into the molten mass they dip another pot containing the zinc. Since the heat thus is evenly distributed over the pot, there is no tendency for the zinc to alloy with the pot, the metal is returned in molten form in a high degree of purity, and the inner pot is spared the eroding effect of the zinc at points of extreme heat, it is claimed.

The end-result to the Martin company has been a great improvement in die materials and a great reduction in the cost of replacement of melting pots. It is believed that the inner pot will last for an indefinite period. It is considered likely that many other industries will be affected by the discovery.

In addition to all this, a cheaper grade of steel may be used for the zinc pots. Under the old system, the pots have of necessity been made of expensive steel.

New Wire & Rod Process

The formation of the Sheet-Wire Corp., Detroit, to enter into the manufacture, with steel and non-ferrous metal companies, of rods, bars and wire by what is described as an entirely new and lower-cost process, has been announced.

According to the new company's president and treasurer, Dean D. Francis, the new process would revolutionize present methods of large scale production of wire and similar products. With it, wire, bars and rods—round, flat or polygonal—are produced by continuous slitting of sheets into many strands instead of by using multiple drawing dies, according to conventional practice. Costly annealing and pickling are said to be avoided in the new process.

The process was originally developed, it is reported, by one of the country's largest producers of steel mill equipment. At the present time, plans for the first installation are already under way with an important steel producer. The process is described as equally applicable to non-ferrous fabrication. In addition to Mr. Francis, who was formerly vice president of the National Bronze & Aluminum Co., the other officers are F. E. Birch and F. L. Armstrong, vice presidents; and A. F. Denham, secretary and assistant treasurer.

● A new rust-proof nail, developed for the boat building industry, is said to have an unusual combination of properties of value to a wide range of industries. The nail is made of Monel metal, and its holding power is derived from a series of sharp, annular rings rolled on during manufacture. The nail can be driven in hard woods without drilling or bending, requires no clinching or counter sinking, and is 2 gages heavier than wire nail of corresponding length. Produced by the Independent Nail & Packing Co., Bridgewater, Mass., the new Monel nail has been called "Anchorfast."

Mining Magnesium from the Sea

For centuries men have considered the possibilities in extracting various valuable materials from sea water. Gold, of course, has figured most prominently in speculation of this type, but in recent years speculation has become an accomplished fact in the case of at least one element, bromine, which the Dow Chemical Co. now extracts on a commercial scale. The same company, sole producers of magnesium metal in America, announce that they are now actually about to produce magnesium from sea water.

Previously, Dow had confined its magnesium metal production to Midland, Mich., where the company's plants are located and where the raw material from which the metal is extracted is taken from the ground. The new sea water extraction plant will be located along the Gulf of Mexico, at Freeport, Tex., where more than 1,000 acres of land has been purchased. It is believed that the new source of magnesium supply will raise Dow's total magnesium production from 12,000,000 to over 25,000,000 lbs. annually. The new construction involved in setting up the sea water plant will call for an immediate expenditure of approximately $5,000,000.

It is estimated that every cubic mile of sea water contains 5,700,000 tons of magnesium. Operating at full capacity, the new Freeport plant will thus have enough magnesium available in just one cubic mile of ocean water to keep it going for 800 yrs. The growing demand for magnesium, with its increasingly wide use in the aviation, bus, railroad and general transportation industries and the manufacture of light-weight, portable tools, household appliances and office equipment, brought the Dow company face to face with the immediate necessity of doubling its production of magnesium alloy.

It is said that magnesium can be recovered from sea water with less effort than from the land. With respect to the site at Freeport, shipping facilities are more than adequate since the Government maintains a 32-ft. channel with a large turning basin for seagoing ships.

Meetings and Expositions

AMERICAN ELECTROPLATERS' SOCIETY, annual meeting, Dayton-Biltmore Hotel, Dayton, Ohio, June 10-13.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, semi-annual meeting, Washington, D. C., June 17.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting, Hotel Pfister, Milwaukee, Wis., June 17-20.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Chalfonte-Haddon Hall, Atlantic City, June 24-28.

PRODUCTION AND MACHINE TOOL SHOW, Public auditorium, Cleveland, June 25-29.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting, The Greenbrier, White Sulphur Springs, W. Va., June 9-14.

Free Service Department

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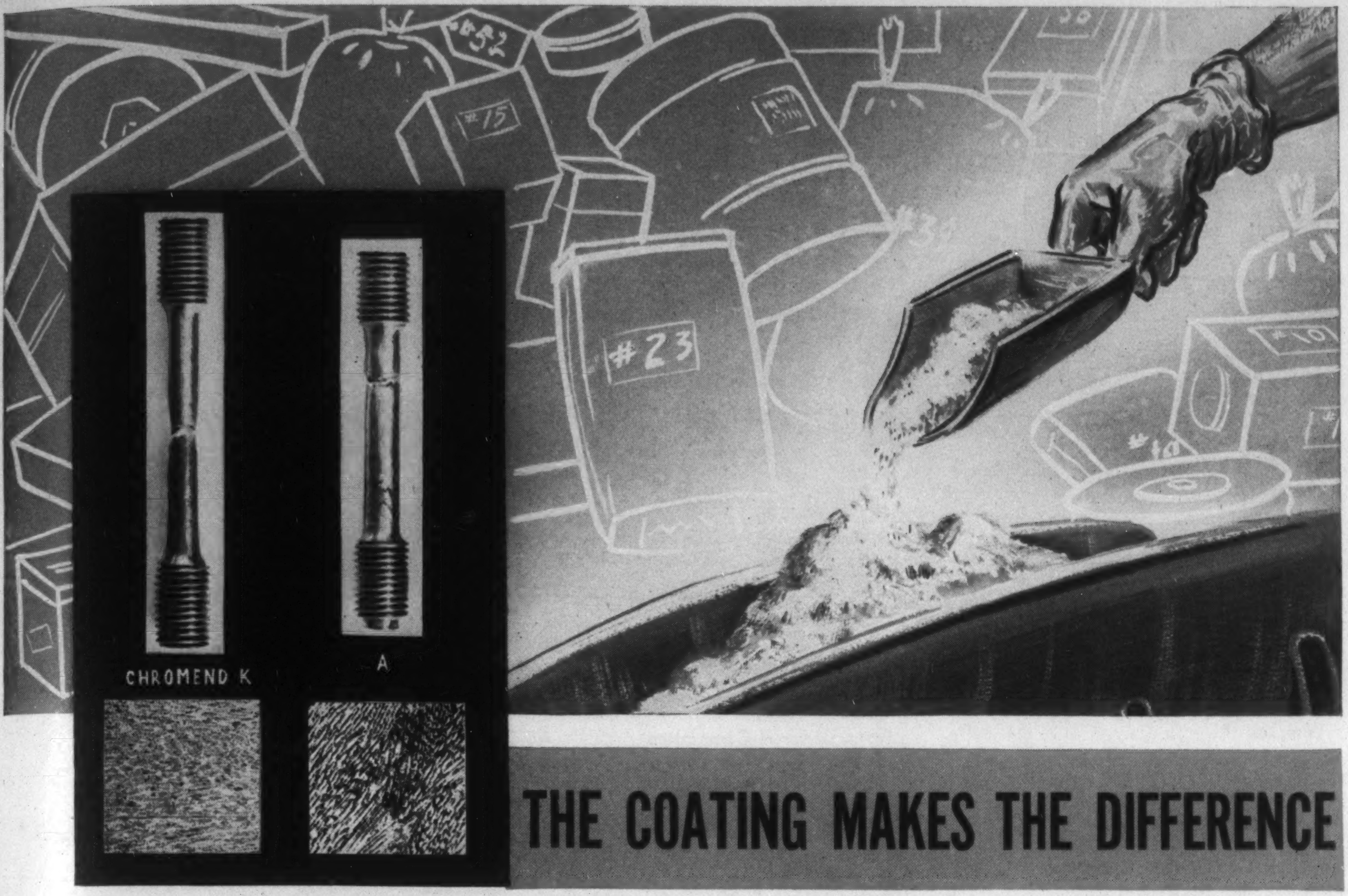
POSITION WANTED: Graduate chemical engineer and metallurgist, eight years practical experience, author several technical papers, married, available on 30 days' notice. Box MA-16.

POSITION WANTED: Superintendent or foreman. Firebrick-layer. 28 years large steel plant. Experienced in design, construction and maintenance, all types of furnaces. Excellent reference. Will go anywhere. Box MA-17.

POSITION WANTED: Chemist and metallurgist, 33 years' experience grey iron, malleable iron, steel. Can handle any foundry problem, analyses, melting, iron mixtures, annealing, heat treating, sand control. Box MA-18.

MANUFACTURERS' AGENT AVAILABLE: A graduate engineer from Johannesburg, South Africa, is in this country arranging to establish himself as manufacturers' agent, for South Africa, of reliable American and Canadian manufacturers. Especially qualified to handle drill and tool steels, electric motors, tools, scientific instruments, electrical appliances and office machines. Box MA-19.



THE COATING MAKES THE DIFFERENCE

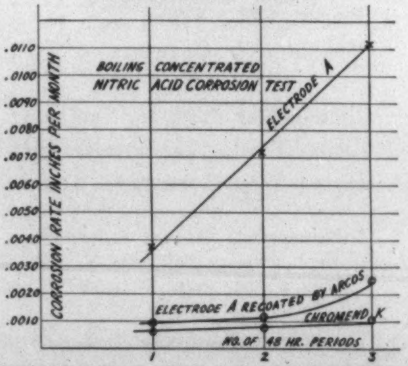
IT is simple to buy a Type 306 (19/9 Chrome-Nickel) stainless core wire and put on a coating to give an electrode that the average operator will O.K. However, it is a different matter to satisfy the *metallurgist*, the *chemist* and the *engineer*.

Arcos Coated Stainless Electrodes—the famous name CHROMEND designates them—produce a weld metal which satisfies the requirements of all these men. So much depends on the coating—as is proved by the test tabulated below. Note particularly that the electrode which gave weld metal of unsatisfactory corrosion rate with its own coating, gave quite acceptable results *when recoated with an Arcos Chromend formula.*

ARCOS CORPORATION
Dept. A, 401 N. Broad St.
Philadelphia, Pa.

	OPERATOR'S REPORT			PHYSICALS	
	Flat Fillet	Flat Butt.	Vertical Fillet	Tensile Strength	Elongation 2 inches
CHROMEND K	Good	Excellent	Good	82000	45.%
ELECTRODE A	Excellent	Good	Fair	79000	35.%
ELECTRODE A Re-coated by Arcos	Good	Excellent	Good	85000	38.%

CORROSION RATE



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THERE'S AN ARCOS STAINLESS ELECTRODE
for every WELDABLE STAINLESS STEEL!

CHROME NICKEL

18/8
8/18
28/3 Mo.
29/9
19/9
19/9 Cb.
18/8 Mo.
18/8 Si.
25/12
25/12 Cb.
25/20
17/25
15/35
13/60
15/85

STRAIGHT CHROMIUM

2% Cr.-Mo.
4-6% Mo.
12% Cr.
16% Cr.
18% Cr.
28% Cr.

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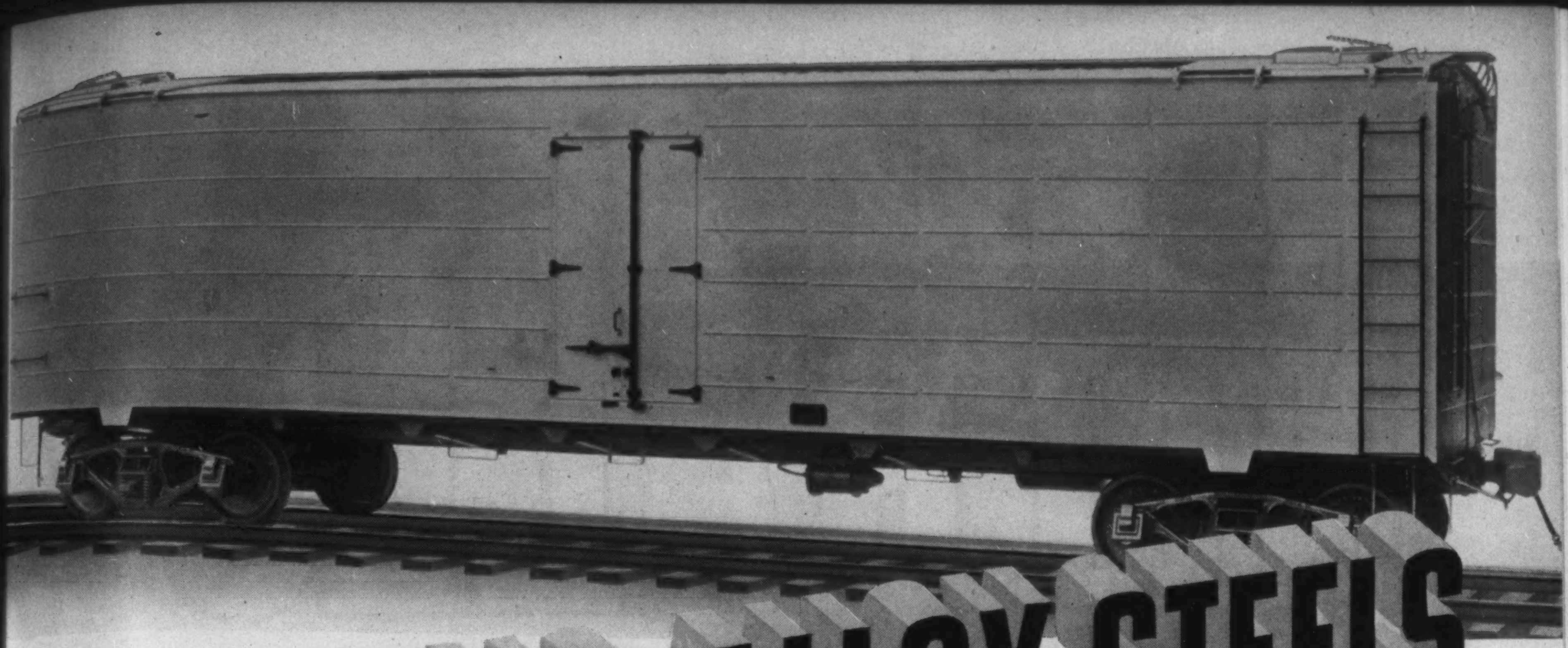

REPUBLIC ALLOY STEELS
—their economic advantages in welded equipment

The first light-weight all-welded refrigerator car was built in January, 1936. Roof, sides, ends and ice racks — all were made from Republic Double Strength Steel sheets. Weight was reduced about 12,000 pounds. After 107,000 miles an inspection showed the car still to be in excellent condition.

With the passing of wrought iron as the common form of commercial ferrous material, it became necessary to develop new and improved methods for welding together the carbon and alloy steels which took its place in industry.

With the introduction of fusion by gas flame or the electric arc and the electrical contact type of welding, the resulting welds generally showed properties different from those of the carbon or alloy steels being welded.

The localized melting and sudden chilling resulted generally in welds which were harder but less ductile than the metal being welded. Where this change in physicals was detrimental, it became necessary to use the lowest carbon steel with a minimum of alloy additions—both in the welding rod and in the parts being welded.

Where steels of high elastic properties and strength are needed, and especially where weight reduction is important, low carbon complex alloy steels properly welded offer distinct advantages over higher carbon plain carbon steel. Such alloy steels at equal or higher yield points show lower weld hardening than the equivalent plain carbon with the added advantages of improved resistance to atmospheric corrosion, improved ductility of weld at room temperature, better retention of toughness at sub-zero temperatures and better creep resistance at elevated temperatures. And, because of their lower carbon they will have better forming qualities.

A case in point—a steel of the low carbon alloy type, such as Republic Double Strength Steel, when welded with rod of the same material will be definitely superior to a welded carbon steel of approximately the same yield strength (50,000 lbs. per sq. in. min.). This strength would require a carbon content of over .45% in plain carbon steel and, even when preheated for welding, the properties of the weld would not compare with the alloy weld in ability to be formed, in resistance to atmospheric corrosion and in ductility.

Alloy steels today are an economic necessity in the manufacture of many types of equipment in which welding plays a part in cutting costs and making stronger, safer, longer-lasting products.

Whatever your problem in steel—Republic's metallurgical staff can help you. Write Republic Steel Corporation, Alloy Steel Division, Massillon, Ohio; General Offices, Cleveland, Ohio.

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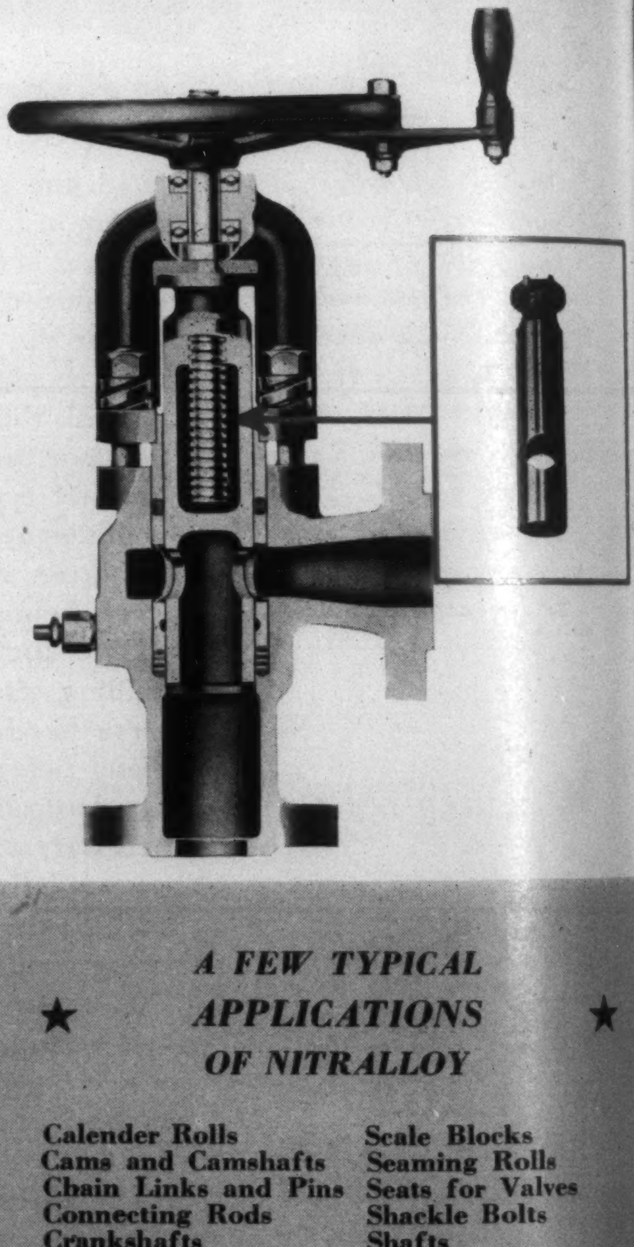
YEARS of service are added to Yarway Seatless Blow-off Valves because each and every one is equipped with Nitralloy Plungers. Yarway considers the Nitralloy Sliding Plunger to be the outstanding feature of their valves which are built for boiler blow-off pressures up to 2500 lbs. These plungers as illustrated take on a surface which "polishes" as it wears thereby insuring longer life to the packing rings by eliminating surface roughness. Just one of the many phases of industry that has accepted Nitrided Nitralloy to give longer life and greater wear resistance to machine parts. For information write The Nitralloy Corporation or any of its listed licensees.



THE NITRALLOY CORPORATION

230 Park Avenue ***New York, N. Y.***

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HOT DIP GALVANIZING solves another problem

THE PROBLEM . . . To produce a slip-proof, lightweight catwalk without incurring the danger of fractures due to rust.

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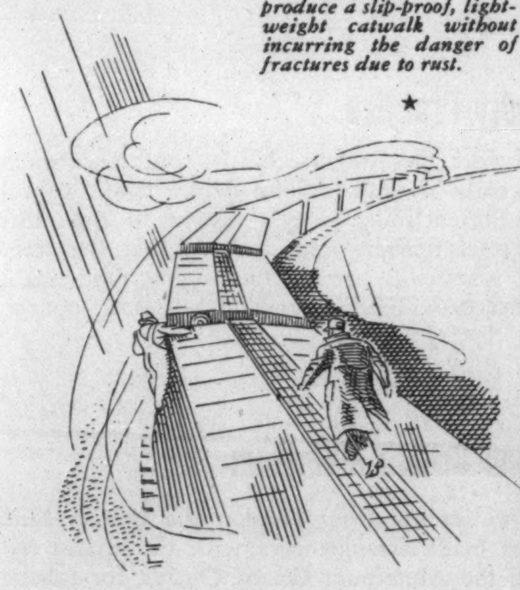

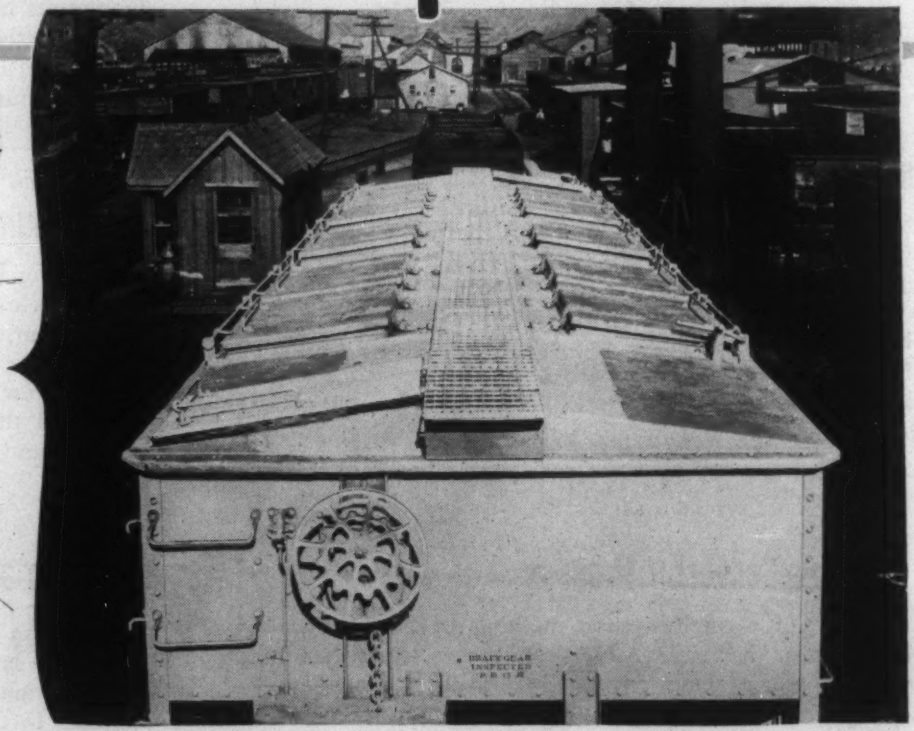

★ *THE ANSWER . . . A Hot Dip Galvanized Open Steel Running Board.*

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Where rust is a factor and excess weight a disadvantage, manufacturers often find that they can safely reduce the size of iron and steel parts by specifying genuine Hot Dip Galvanizing. Hot Dip Galvanizing guarantees maximum rust protection at minimum cost. It means an adequately thick coating of zinc and a union between zinc coating and base metal that makes each an inseparable part of the other. There is no *safe* substitute for genuine Hot Dip Galvanizing. Patronize our members and know that you are getting only this quality type of work. Write for literature. American Hot Dip Galvanizers Association, Inc., American Bank Bldg., Pittsburgh, Pa.

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trends

By Edwin F. Cone, Editor

Foundrymen

The trend in the conventions and expositions of the A.F.A. is definitely toward better technical sessions and complete exhibits. This was characteristic of the event held in Chicago in May. A feature of the technical sessions, which were well attended, was a limited number of papers which insured good discussion—a practice which could be adopted by other societies. While not the largest exposition, its character and beauty were outstanding.

The Cupola-Converter Process

A report of a committee on methods of producing steel for castings at the recent A.F.A. convention states that three new developments have combined to make the cupola-converter process much more attractive than formerly. The first is the hot-blast cupola, melting an all-steel scrap charge; the second is the further development of the soda-ash treatment of the molten iron to remove sulphur; and the third is the adaptation of the "electric eye," or photoelectric cell, to the automatic control of the blow of the converter.

Sulphur Removal by Soda Ash

As an example of what can be done in the removal of sulphur from molten iron by treatment with soda ash, reliable testimony is that cupola iron, which averaged 0.158 per cent S in samples taken from the spout of a cupola, was reduced to a content of 0.042 per cent S—the average of 11 ladles.

Cupola Hot Metal for the O-H

"Tests made have been reported so favorable that the next year should see some installations of cupolas to supply hot metal for open-hearth furnaces." Advantages cited are utilization of a cheaper charge, use of the highly efficient cupola for melting, and increasing the capacity of the open-hearth.

Austempering

Evidences are accumulating that the austempering heat treating process, as developed for thin sections of steel and described by Legge in our August issue in 1939, is applicable with beneficial results to malleable iron. Cowan in a paper on "The Heat Treatment of Malleable Iron" before the A.F.A. in May discussed this. Bartholomew, of the United Shoe Machinery Co., has studied the austempering of cast iron with interesting results.

Stockholders and Technical Progress

Regarded by many as an innovation was the discussion by R. E. Zimmerman, vice-president in charge of research of the U. S. Steel Corp., before a recent stockholders' meeting, of the results of applying a modified procedure of the austempering method of heat treating steel to a wrench. Injecting reports of technical progress into such a business meeting is distinctly a striking trend.

Steel Foundry Practice

Speaking before the Rutgers, N. J., conference on foundry practice early in April, John Howe Hall, consulting metallurgist, Philadelphia, gave a resumé of the processes used in the steel foundry and declared that the trend of the last few years was toward thoroughly oxidizing steel heats and then deoxidizing immediately before pouring to secure sound, ductile castings.

Canadian and British Aluminum

According to reports from London the British Ministry of Supply has made arrangements with the British Aluminum Co. and the Aluminum Co. of Canada for substantial increases in the output of the metal. The Canadian increase is stated to be sufficient to make that country's total capacity alone almost equal to that of Germany. The entire output of the two companies has been purchased by the Ministry for the balance of 1940 and the whole of 1941.

Prices for Aluminum

The trend in the prices for aluminum ingots and for fabricated products is downward. The Aluminum Co. of America recently reduced its quotation for 99 per cent plus virgin ingot aluminum from 20c to 19c per lb. While this is not the lowest price on record, it is the lowest since 1923 with the exception of a 19 to 22c range from 1935 to 1938. The highest quotation in the last 29 yrs. was 53c to 67c in 1916 and the lowest 16.50c to 23c in 1922.

Brazing Alloys

The amount of joining being done with the standard silver brazing alloys in industry is impressive, according to Robert H. Leach, vice-president of Handy & Harman, in a paper before the recent annual convention of the International Acetylene Association.

(Other "Trends" on page MA 372)

Meehanite

A FEATURE OF THE NEW *CINCINNATI* HYDRAULIC UNIVERSAL GRINDING MACHINES

Chosen—"Design of the Month" in February by "Electrical Manufacturing"

The castings used in the construction of this and other products of the Cincinnati Milling Machine Co. and Cincinnati Grinders Incorporated are *Meehanite* Castings. Why? Because precision machines, made the way CINCINNATI builds them, require castings that have:

1. **Dependable High Physical Properties and Machinability.**
2. **Freedom from Warpage for More Constant Alignment.**
3. **Good Damping Qualities for High Speeds.**
4. **Suitable Characteristics for Maintaining Dimensional Accuracy for Precision Operations.**
5. **Predetermined Uniform Grain Structure.**

The *Meehanite* Bed Casting (illustrated) is one of the vital parts contributing such characteristics, particularly strength (tensile—over 35,000 lbs. per square inch) and unusual resistance to warpage in the face of widely varying temperatures.

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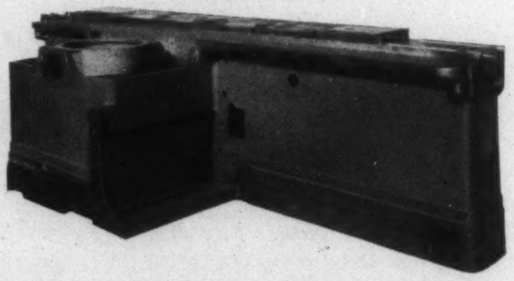

Meehanite Bed Casting for "CINCINNATI" Hydraulic Universal Grinding Machine.

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Chattanooga, Tenn.	Ross-Meehan Foundries
Chicago, Ill.	Greenlee Foundry Company
Cincinnati, Ohio	Cincinnati Grinders Incorporated
Cincinnati, Ohio	The Cincinnati Milling Machine Co.
Cleveland, Ohio	Fulton Foundry & Machine Co.
Denver, Colo.	The Stearns-Roger Mfg. Co.
Detroit, Mich.	Atlas Foundry Co.
Flint, Mich.	General Foundry & Mfg. Company
Hamilton, Ohio	Hamilton Foundry & Machine Co.
Irvington, N. J.	Barnett Foundry & Machine Co.
Los Angeles, Calif.	Kinney Iron Works
Milwaukee, Wis.	Koehring Company
Mt. Vernon, Ohio, Grove City, Pa.	Cooper-Bessemer Corporation
New York, N. Y.	The American Brake Shoe & Foundry Co.
Oakland, Calif.	Vulcan Foundry Company
Orillia, Canada	E. Long, Ltd.
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Pittsburgh, Pa.	Meehanite Metal Corporation
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Rochester, N. Y.	American Laundry Machinery Co.
Springfield, Mass.	Fleming Foundry Co.
St. Louis, Mo.	Banner Iron Works
St. Paul, Minn.	Valley Iron Works
London, Eng.	The International Meehanite Metal Co., Ltd.
Waterloo, N. S. W.	Australian Meehanite Metal Co., Ltd.

trends

By Edwin F. Cone, Editor

Exothermic Alloys for Steelmaking

The use of exothermic alloys in steelmaking is attracting keen interest. Two such products are mentioned in the report of the committee on methods of producing steel for castings before the steel division of the A.F.A. One is the Stritmatter process in France and the other is the "Chrom-X" process in this country. The Chrom-X alloys are used for alloying steel by placing a known quantity, container and all, either in the furnace or the ladle. The hot steel starts the exothermic reaction producing molten ferrochromium and a fluid slag. Alloying is described as being thus accomplished quickly without changing the temperature of the bath. It is available as both low and high carbon grades. The low-carbon Chrom-X, added to the furnace, has been used to make 5 to 12 per cent Cr steels in an open-hearth furnace, it is stated.

Spiegel Imports

Our imports of spiegeleisen in 1939 took a decided jump upward, according to official Government data. The imports last year were over 38,560 gross tons while in 1938 they were only 17,260 tons with 17,895 tons reported for 1937. Previous to 1937, the data do not segregate this commodity from ferromanganese.

Rolled Zinc

The American output of rolled zinc (sheet zinc, boiler plate and strip zinc) last year was 61,882 net tons or 35 per cent in excess of the 45,875 tons in 1938, according to the Bureau of Mines.

Slab Zinc

The apparent consumption of primary slab zinc was the highest ever recorded last year and was 62 per cent above that of 1938, says the U. S. Bureau of Mines. Brass-making industries used approximately 70 per cent more zinc last year than in 1938, although this industry normally accounts for less than 30 per cent of the total consumption.

Open-Hearth Operations

That there is widespread interest in the open-hearth furnace and that the problems involved are increasing in number was demonstrated by the attendance at the annual convention of the Open-Hearth Committee of the A.I.M.E. in Pittsburgh in April. Over 700 were registered at the combined meeting of this committee and the blast furnace committee, the largest on record.

There was increasing evidence that both the large and small open-hearth producers are taking a more active interest in the discussions. Practically every open-hearth producer was represented.

Acid Open-Hearth

For the first time in the 15-year history of the Open-Hearth Committee of the A.I.M.E., sessions were devoted to the acid open-hearth at the 23d convention this year. Previously all deliberations have been confined to the basic open-hearth. Keen interest and a large attendance characterized the acid open-hearth meetings and it was evident that there are many important problems in that field.

Alloy and Stainless Ingot Exports

Last year the foreign demand for American alloy steel ingots, billets, blooms, etc., showed a marked tendency to expand. Official Government statistics show that in 1939 over 48,500 gross tons of such material, including stainless steel, was exported as compared with 7,736 tons in 1938 and 7,232 tons in 1937. Earlier statistics are not available. The 1939 outgo is probably a record.

Alloy Steel Forging and Castings Exports

Foreign consumers of American stainless and alloy steel forgings were more active in 1939 than in the two previous years. Our exports of this material last year were 2,013 gross tons while in 1937 and 1938 they were only 933 and 855 tons respectively.

The trend for such demand for alloy and stainless steel castings has been erratic—1,647 tons in 1937 with 1,154 tons in 1938 and 1,385 tons in 1939.

Molybdenum

Shipments of molybdenum in 1939 established an all-time high at 32,415,000 lbs., according to the Bureau of Mines. This was an increase of 26 per cent over 1938 and 8 per cent over 1937. The estimated value of the 1939 shipments was $22,157,000.

The upward trend in production of molybdenum in the United States which began in 1933 was, however, arrested in 1939 with a decrease of 9 per cent from 1938. The production last year was 32,347 net tons of concentrates containing 30,324,000 lbs. of molybdenum.

Exports of molybdenum concentrates last year were very high at 43,554,310 lbs., or 21,777 net tons.

(Additional "Trends" on page MA 370)

SILICON CARBIDE, YES, BUT THAT'S NOT ALL

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PERHAPS it is only natural that there is an impression that The Carborundum Company makes only silicon carbide refractories. This company pioneered the development of super refractories, working with Carborundum Brand Silicon Carbide. And today The Carborundum Company is the largest manufacturer of this type of refractories.

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"ALFRAX" B	(3 varieties)	fused alumina
"MULLFRAX" S	(6 varieties)	sillimanite type
"MULLFRAX"	(5 varieties)	electric furnace mullite
"ZIRCOFRAX"	(4 varieties)	zircon
"ALFRAX" BI	(5 varieties)	super refractory insulating
"INFRAX"	(1 product)	insulating refractory
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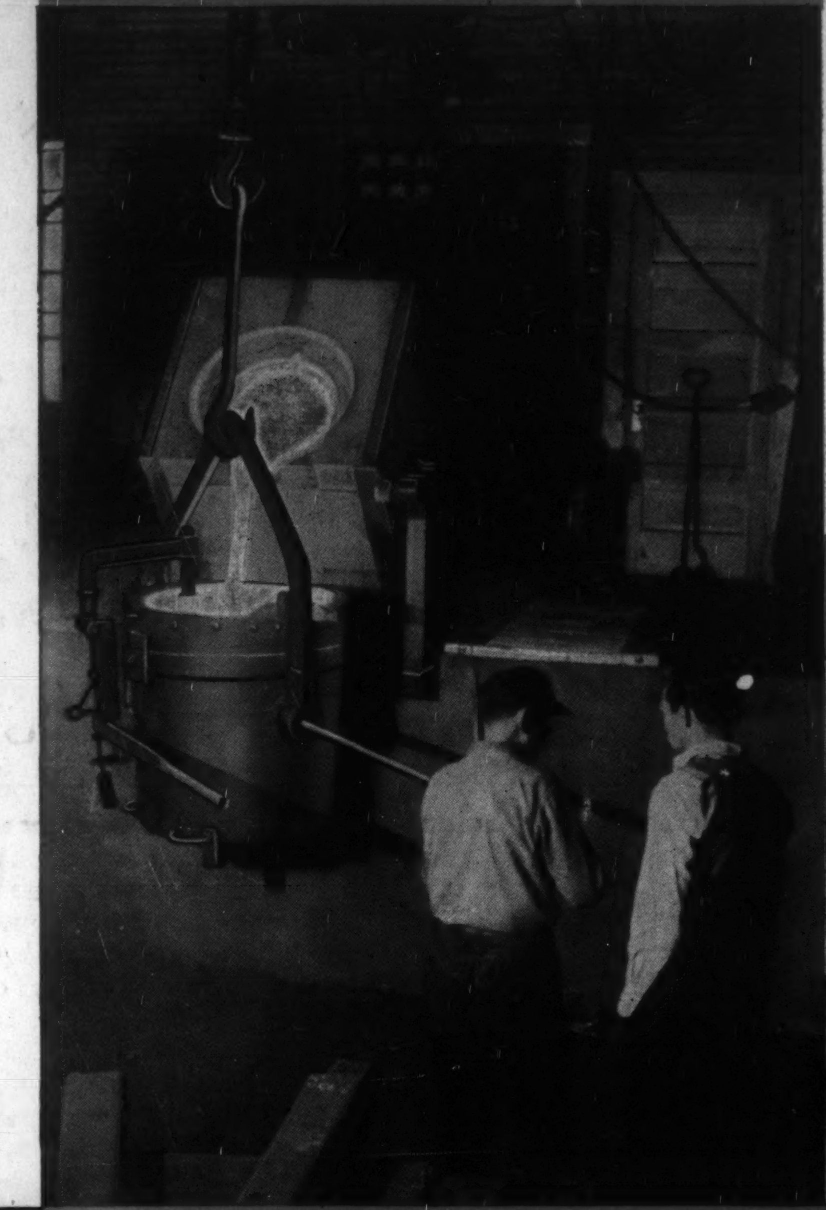

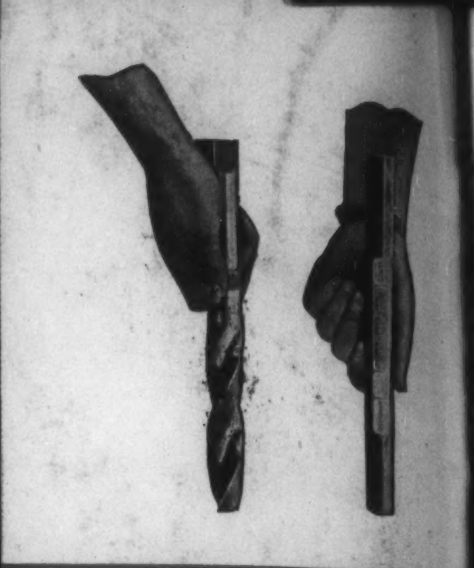

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